AN EXPERIMENTAL STUDY OF SILENT THINKING

BY

RUTH S. CLARK, Ph.D.

ARCHIVES OF PSYCHOLOGY
Edited by R. S. WOODWORTH
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CHAPTER I.

INTRODUCTION

In order to understand thinking from a point of view other than logical, it is necessary that thought processes be submitted to experimentation and be carefully observed in respect to their inherent characteristics. The results described below have been based upon an experimental study of thinking in relation to its physiological and psychological aspects. Not only has thinking in this investigation been submitted to observation under controlled conditions, but objective measures have also been made of its various characteristics, so that as little dependence as possible has been placed upon the subjective estimates of those thought processes which were being studied.

The term "silent thinking" has been used throughout this report to describe the processes carried on by the mind in its attempt to reach new conclusions, which are controlled in their development by the demands of a problematic situation. Subjects have been asked to solve problems without consciously making use of any explicit form of behavior. The value of the solution was not taken into account. Any solution offered by the subject, which to him was new, was accepted. It is such processes as these that have been submitted to experimentation in this investigation and that have been studied from the psychological and physiological view points.

There have been few attempts to deliberately observe under controlled conditions the silent reaching of new conclusions. Ach, in his study of thought,[1] was interested to discover whether extra-conscious determining tendencies, set up by a given task, could yield new products which would not be the result of reproduction. He exposed to the view of his subjects separate nonsense syllables to which the subjects were at times required to give rhymes, at times examples of alliteration. For each experiment he recorded the time and retrospections of the subject. As a result, he stated that new conclusions could be reached by the influence of extra-conscious determining tendencies, and that the novelty of the conclusions might be due to successive association, as when the given stimulus was followed by the response for the first time, or to simultaneous association, as when a syllable made up of a new combination of letters was produced by the subject.[1]

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[1] Ach, N. Über die Willenstätigkeit und das Denken, 1905, p. 196.

Messer, in his experimental investigation of thinking,[2] stated that judgments may differ in relation to other conscious processes in the degree of novelty which they possess.[3] Some of the tests in certain series of his experiments produced conclusions which were characterized as novel by the subjects. From a study of these reactions, he found "activity" especially characteristic of original thinking.[4] This activity he described as the voluntary production of relations and the mental processes of seeking, reflecting, proving, resolving, accepting and rejecting. The more original and the more prolonged the thinking, the more pronounced were these activities. When the thinking was expecially hurried, as in passing rapidly over a minor premise to reach the conclusion, these mental processes were rarely reported. Later on in his report[5] Messer classified two of these activities, seeking and reflecting, as "Bewusstseinslagen,"[6] being imageless states. Whether or not the other activities were similar states, it is impossible to say. Messer also found[7] that the influence of the "Aufgabe" was more marked in original thinking than in reproduction. Something was "meant" and "intended" in the formation of original judgments which was not so characteristic of the recall of familiar material.

Another contribution from the Würzburg school was that of Bühler.[1] He purposefully limited his observations of thinking to the study of the reaching of new conclusions, eliminating reactions which were mechanical or even familiar. In order to arouse in his subjects original thought, he read to them passages from Nietzsche, Marie vonEbner, Sachenbach, Pauly and Otto Weiss, requesting them to take some attitude toward them, answering either yes or no. He then recorded their reaction times and retrospections.

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[1] Ib. p. 208.

[2] Messer, A. Experimentelle-psychologische Untersuchungen über das Denken. Arch. f. d. ges. Psych. 1916 VIII. pp. 1-224.

[3] Ib. p. 115.

[4] Ib. p. 125.

[5] Ib. p. 183.

[6] This term, suggested by Marbe, appeared for the first time in the work of his pupils, Mayer A. and Orth, J., Zur qualitativen Untersuchungen der Association. Zsch. f. Psych. 1901. XXVI. pp. 1-13.

[7] Ib. p. 126.

Bühler found, as did Ach and Messer, that thinking was dependent upon the influence of determining tendencies set up by the task.[2] In respect to the constituent parts of the thought processes, the subjects reported the presence of sensory images, both verbal and concrete. Inner speech, however, did not invariably appear.[3] The subjects also described sensory experiences of spatial directions and of changes in direction.[4] "Bewusstseinslagen" were reported as well, such as feelings of doubt, astonishment, and expectancy. But these were not all. There were certain states of mind, "Gedanken," "thoughts about" this or that object, which were described as vivid, convincing, and definite, although they contained no sensory elements. Ach had found similar states of mind reported by his subjects.[5] These he had termed "Bewusstheiten." Such states of mind were also reported by Messer.[6] He described them as "unanschaulichen Wissen" and included them under the head of "Bewusstseinslagen."

Imagery and "thoughts" Bühler decided were the main factors which guided thinking.[7] Imagery, however, was found to have been too fragmentary and sporadic to be the basis of continuous thinking. Since thinking was as distinct with images as without, and in many instances was remembered, while the images which accompanied it could not be recalled, he concluded that "thoughts about" objects were the fundamental constituents of the thought process. He believed that these thoughts were irreducible units, resisting analysis. Three types of these thoughts were recognizable: the consciousness of a universal principle, the consciousness of the relation between one part of thought and another, and the consciousness of the relation of the thinker to the thought, "intention." The difficulty lay in his inability to describe these various kinds of thought. Bühler believed that the "thought about" something sensory or imaginal was neither sensory nor imaginal, as an object and its meaning are distinct. He therefore concluded that "knowledge about" something involved an added problem: the description of that knowledge, which was still to be determined.

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[1] Bühler, K. Tatsachen und Probleme zu einer Psychologie des Denkvorgänge. Arch. f. d. ges. Psych. 1907. LX. pp. 297-365.
[2] Ib. p. 315.
[3] Ib. p. 319.
[4] Ib. p. 315.
[5] Op. cit. p. 210.
[6] Op. cit. p. 175.
[7] Op. cit. p. 316.

Similar results were simultaneously obtained in this country from the experimental work carried on by Woodworth.[1] His subjects were asked questions which were considered difficult enough to stimulate real thinking. Ordinarily the subjects were asked to give their retrospections at the completion of their solutions, but frequently the experimenter interrupted them before they had reached their conclusions, asking: "Any visual pictures?" "Any words heard?" "Any feelings of bodily movement?" From the study of these results and from his own introspections, Woodworth concluded that thinking contains elements "wholly irreducible to sensory terms." Frequently the content of thinking was merely a "particular feeling of the thought in question," a state of mind apparently identical with Bühler's "Gedanke." In describing one of his own thought processes, Woodworth was even able to add: "When thought is really effective, when some new insight is gained, the words are absent, though they soon come tagging after."

An experimental investigation of inference was carried out in Zurich by Störring.[2] When the simple syllogisms were presented, Störring found that, after perceiving the propositions, the subject quickly received an idea of the whole problem by means of visual imagery, the middle term being recognized as common to both premises. The conclusion seemed to follow immediately, as if it were a direct result of the perception.[3]

In syllogisms where more complex relations were introduced, however, the drawing of the conclusion was dependent upon the mediation of other processes, by means of which the relations of the middle term had to be made clear before the conclusion could be drawn. Occasionally the subjects reported a "synthesis of relationships" which presented a view of the whole so clearly that the conclusion followed directly[1] In some cases the subjects reported the presence of a "Gedanke" of the progress of the thought,[2] before drawing their conclusions.

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[1] Woodworth, R. S. Imageless Thought. Journ. of Phil. Psych. etc. 1906, 111. pp. 701-708.

[2] Störring, G. Experimentelle Untersuchungen über einfache Schlussprozesse. Arch. f. d. ges. Psych. 1908, XL. pp. 1-127.

[3] Ib. pp. 14 ff.

Other contents of consciousness described by the subjects included feelings; images, both concrete and verbal; sensations of movement in the eyes, hands, and chest; "Bewusstseins" of certainty, identity, possibility, opposition, etc.; while the "Gedanken" ranged from simple thoughts of relations to the consciousness of universality. The term "Bewusstseinslage" was not used by the subjects in their reports or by the author in classifying their imageless states. The terms "Bewusstsein" and "Gedanke" were preferred, and at times use interchangeably.[3] An attempt, moreover, was made to study further the nature of the Gedanke. The subject was asked not to react until his thoughts about relations were as clear in his mind as possible. As a result, concrete and verbal imagery and sensations of movement were frequently reported.[4] Other results, however, showed that when similar syllogisms were repeatedly presented to the same subject, in some cases the sensory elements disappeared, while in other cases they became more prominent.[5] When the subjects were asked to react as quickly as possible, the imagery was usually reported less clear.[6]

Imagery apparently played an important part in the thinking of his subjects, for they frequently reported that they used images of lines, circles, and cubes in order to make the meaning of the relationship between the terms more clear.[7] However, imagery could not have been necessary to the development of the conclusion, for in some instances it was absent,[8] while at other times it was too weak to produce a conclusion, even if a feeling of certainty accompanied the conclusion reached.[1]

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[1] Ib. p. 22.
[2] Ib. p. 27.
[3] Ib. pp. 26, 27.
[4] Ib. pp. 50, 69, 73, 112.
[5] Ib. pp. 76, 105.
[6] Ib. pp. 17 ff.
[7] Ib. pp. 10, 53, 81.
[8] Ib. pp. 9, 28.

Finally, in Störring's results there were more references made to the part played by movement than in any of the works of his predecessors. Eye movements were reported, not only in perceiving the positions of the various terms, but in connection with visual imagery.[2] Arm movements seemed to represent relationships of left and right.[3] The movements caused by breathing were also noted, but not measured.[4] Movements, he concluded, either disappeared in the presence of imagery, or they were overlooked in the description because of the attention given to the image.[5]

An investigation caried on by Miss Lunniss at Bedford[6] closely resembles that of Bühler's. Short problems were given the subjects to which each replied either affirmatively or negatively. The time for each reaction was taken and the subjects recorded all that had taken place in consciousness from the time of hearing the question to the time of giving the answer. The experimenter then gained what further information was necessary to make these protocols clear by asking "judicious questions," and recording the answers.

Imageless thought was found to have characterized 26 of the 123 reactions, the remaining responses having included imagery.[7] Imagery was found to have been necessary to original thinking for one subject, to have been occasionally necessary in the case of another subject, and quite irrelevant to thinking for the third subject. No connection could be found between the time expended in thinking and imagery, for short reactions were as apt to have imagery as not.[8] In the case of two subjects, difficulty in the thinking seemed to account for imagery in some cases.[9]

Instances of Bühler's three kinds of "Gedanke" were also found.[10] These mental processes were not described as such by the subjects, but were interpreted in this way by the experimenter after an analysis of the subjects' protocols. They seemed to be an essential part of the judgment process. Moreover, there were no "ways of knowing" which played a part in the thinking which could not be included within one of the three classes described by Bühler, provided they were interpreted broadly enough by the experimenter.[1]

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[1] Ib. p. 6.
[2] Ib. pp. 24, 25, 42, 107, 125.
[3] Ib. pp. 17, 42, 44, 45.
[4] Ib. p. 56.
[5] Ib. pp. 29, 59.
[6] Lunniss, B. A. A Study of Thought Processes. Psych. Studies from Bedford College, Univ. of London, 1914. pp. 67-161.
[7] Ib. p. 76.
[8] Ib. p. 80.
[9] Ib. p. 81.
[10] Ib. pp. 85 ff.

Various "Bewusstseinslagen" were also described by the subjects.[2] In fact, the experimenter found that an attempt to enumerate them all would be too confusing. In addition to those already described by Messer[3] and Bühler,[4] the experimenter found a distinct "consciousness of the manner of mental procedure," a "questioning attitude" and a "laboratory attitude." These "conscious attitudes" seemed to have been distinct from the "ways of knowing" in the minds of the subjects, and yet the experimenter acknowledged that the two kinds shaded off very closely into one another.[5] Unlike the "ways of knowing," however, the "conscious attitudes" could be absent when judgments were found and so were obviously not essential to the thinking.

Finally, the evidence which more conclusively showed the value of Bühler's "ways of knowing" was that reactions for which no formation of judgments were required were characterized by the lack of these "ways of knowing," especially the "consciousness of the relation of the present data offered for apprehension to some whole already apprehended."[6]

Betts, in an experimental study of imagery,[7] included an investigation of the part played by images in thinking. After having given his subjects a problem to solve, he asked them to write, instead of a description of their solution, an account of the mental processes which had meanwhile been taking place. The subjects were skilled in introspection and were used to this method of interrupted thinking. The following mental processes were described: imagery, sensory elements, personal feelings, elements of relation and of meaning, feelings of effort, strain and attention.[8]

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[1] Ib. p. 100.
[2] Ib. pp. 117 ff.
[3] Op. cit. pp. 175 ff.
[4] Op. cit. p. 315.
[5] Op. cit. p. 123.
[6] Ib. p. 139.
[7] Betts, G. H. The Distribution and Function of Imagery. T. C. Contr. to Ed. No. 26, 1909.
[8] Ib. p. 62.

Imagery was not reported by all the subjects and by its very nature it seemed to be merely incidental to the thinking. The experimenter finally concluded that imagery had been overestimated as an important mental content.[1] Images seemed to apear only when thinking was "baffled" or when percepts would ordinarily have been of use.[2] Consequently the most "successful" thinking had apparently the least imagery.[3] The imageless states of consciousness were not analyzed by Betts.

Dr. Fernald, in her investigation of individual differences in imagery[4] included a study of the part played by imagery in the solving of problems. Problems in both mathematics and physics were given to the subjects.[5] This kind of problem was selected with the hope that concrete rather than verbal imagery would be aroused. The detailed results of these experiments were not published, but the experimenter's conclusions were that the individual's type of imagery, which was found to have characterized other kinds of mental processes, was found to prevail in thinking as well. Visual imagery, however, seemed more important to the solving of the mathematical problems, while verbal imagery was emphasized more in the solution of the physics problems.

Dr. Fernald also concluded that, in solving the most difficult problems, more attention was required for the performance of the work itself, while less attention could be paid to imagery and consequently a sparsity of images was reported.[6] This seemed a probable explanation of some imageless states. However, the presence of imagery was more frequently reported with an increase in the novelty and difficulty of the problem. In fact, the experimenter was able to devise problems which invariably required the presence of imagery by making the problem sufficiently difficult and at the same time denying perceptual aids to the subject. Therefore, imagery played an important part in original thought. But the experimenter did not deny the possibility of other factors being equally important or even more so than imagery.

From this survey of the studies which have been made of silent thinking, it is clear that very little has been done to observe the detailed characteristics of thought under experimental conditions. Problems have been given to subjects skilled in introspection, the time of the reaction has been recorded and the retrospections of the subject have been studied. The mental processes described by the subjects have been interpreted and classified by the experimenter and the relative importance of each to thinking has been determined. In general, mental images have been found to be unnecessary to the reaching of a novel conclusion. They often appear in thought processes, but they do not always seem relevant to the content of the thought. Other mental processes described by the subjects have been imageless states, most frequently characterized as conscious "attitudes" or as "thoughts about" some concrete object. These have been considered by most experimenters to be essential to thought. References to sensory states of consciousness during thinking, such as the awareness of movements, have been merely incidental to the reports of these experimenters and no attempt seems to have been made to study them or to note their importance.

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[1] Ib. p. 98.
[2] Ib. p. 70.
[3] Ib. p. 94.
[4] Fernald, M. R. The Diagnosis of Mental Imagery, Psych. Rev. Mon. 1912. No. 58.
[5] Ib. p. 95 ff.
[6] Ib. pp. 36 ff.

CHAPTER II.

GENERAL PROCEDURE

In distinction to the above methods of procedure, the present investigation[1] has confined itself to a compilation of as many objective measures of the physiological and psychological aspects of thinking as possible, leaving to the experimenter little or no chance for rendering an interpretation of the results. As the bone of contention between the investigators has been based upon a consideration of the prevalence and importance of imageless states as compared with imagery, it was believed best in this investigation to use every means to arouse imagery, and to record the results.

Problems were given which were likely to require for their solution images[2] in the various sense fields, and the subjects were asked to give an account of the mental processes which occurred between the time of the presentation of the problem and the moment at which the subject was aware of an original conclusion. Their attention was especially called, in some sittings, to the presence of imagery during the solution of the problem. Only two subjects were conversant with the work from the Würzburg Laboratory in detail, while the other subjects, as their introspection showed, gave little evidence that they were familiar with imageless thought as such.

The experiment was carried on in a dark room lighted by but one bulb in the center, all other distracting objects having been removed from sight. A continuously recording kymograph was used which was run by electricity. The time in fifths of a second was given by means of a vibrating reed, and recorded by one of the needles. A second needle was connected with a key on the arm of the subject's chair while the third needle recorded the taps of the experimenter's key.

The apparatus was placed on a large table in the center of the room (See Fig. 1.) The motor and gear wheels were covered by a box lined with cotton in order to reduce their sound. All apparatus was screened from the view of the subject who sat about four feet away from the end of the table.

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[1] This study was completed in 1919.

[2] Betts pointed out the prevalence of imagery in the solution of certain problems where percepts would ordinarily be of service. The Distribution and Function of Imagery, p. 70.

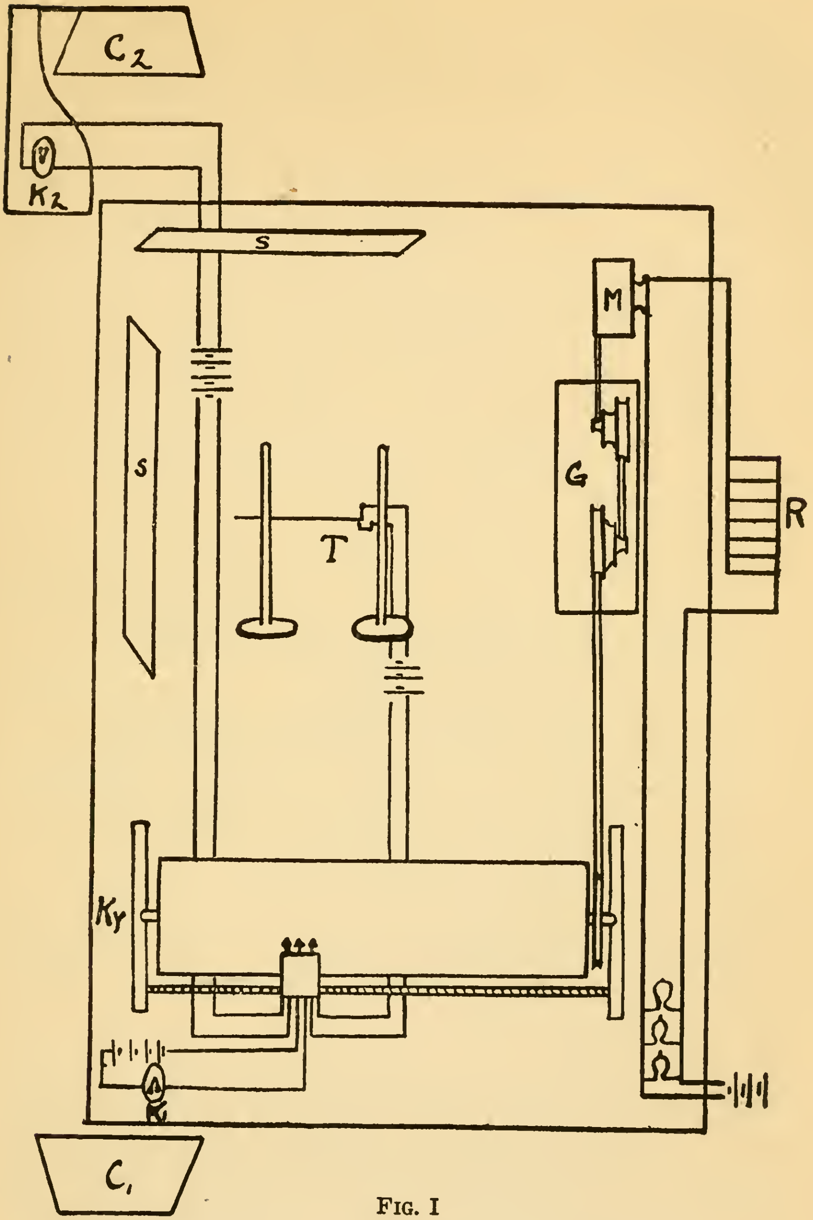

FIG. I

Ky.	Kymograph.
R.	Rheostat.
G.	Gear Wheels.
M.	Motor.
S.	Screens.
C_1	Experimenter's Chair.
C_2	Subject's Chair.
K_1	Experimenter's key.
K_2	Subject's key.
T.	Vibrating Reed.

The experimenter sat at the opposite end of the table facing the apparatus with her hand on the key, which was hidden from sight of the subject. Thus it was possible for the experimenter, who was facing the subject, to observe his movements and to indicate the nature of them on the kymographic record by pressing her key, making use of a code of signals previously determined.[1] As this key was out of sight of the subject, this description of movements on the part of the experimenter was carried on unknown to the subject, who believed that merely the time of the reaction was being recorded. The noise of the apparatus was not loud enough to interfere with the giving of the problem by the experimenter or the description of retrospections by the subject; it being a low rumble which seemed to offer no distraction. The subjects were ten graduate students in psychology at Columbia University; five men and five women.[2]

The problems were carefully selected to meet the following requirements:[3]

(1) They must demand no form of explicit behavior for their solution, silent thinking alone being desired.

(2) They must present a problem for which a novel conclusion could be devised by the subject.[4]

(3) They must not call for mere book knowledge where verbal elements would naturally play the important part.

(4) They must not be arithmetic problems, as fixed habits have usually grown up about this kind of mental activity and its products can hardly be termed novel.

(5) They must be stated simply so that no confusion can arise as to their meaning.

(6) They must not call merely for the answer yes or no, as the greatest possible variety in response was desired.

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[1] See Appendix p. 89.

[2] To these subjects: The Misses Cornell, Corwin, Gough, Wilkins and Mrs. Berliner; the Messrs. Achilles, Brimhall, Gates, Jackson and May, I wish to express my deepest gratitude for their generous cooperation. I wish also to thank the Neurological Department of the School of Physicians and Surgeons for the use of their instruments; and especially their assistant, Mr. De Bra, for his help in recording the minute bodily movements. To Professors Woodworth and Cattell and to Dr. Poffenberger, I am likewise indebted for inspiration and helpful suggestions.

[3] See Appendix, p. 90 ff.

[4] If the problem was one familiar to the subject, it was eliminated. Moreover, as soon as the subject had reached his conclusion, he was asked if it were new to him. If not, the results were not included in this report.

(7) They must present situations, which, though not common, might happen in the experience of anyone, and so disclose mental processes which are ordinarily used to solve the problems of everyday life.

(8) They must not arouse emotional states any more than necessary as this would needlessly introduce extraneous mental processes.

As soon as the problem was given to the subject, objective records were taken on the kymograph during the thinking. After the subject had signalled to the experimenter that he had solved the problem, he was asked the following questions, always in the same order:

1. Will you describe the course of events?
2. Was the conclusion novel? How much so?
3. Was imagery present? Kind?
4. Was there more than one kind of imagery present at once? Describe.
5. Was imagery present throughout the thinking?
6. Was there a feeling of progress throughout? If not, Where?
7. Did your mind wander? When?
8. In what terms did the novel part of the conclusion present itself?
9. Did you at any time have a desire to speak?

In spite of the fact that many of these questions called for information which had already been given in answer to the first question, they were nevertheless always asked after each reaction. No other questions were asked and the answers to these were recorded verbatim. The subjects used their own terms to describe the contents of their thought processes. They were at no time influenced by suggestion to change these expressions or to search for any special kind of mental elements, with the exception of imagery, as noted above.

An attempt was first made to determine the individual differences in mental images of the various subjects. Each one was asked to respond to the Seashore Questionnaire,[1] giving a numerical estimate of the degree of vividness of each image. From these results a curve of each subject's capacity for vividness of each kind of imagery was drawn. The subject's type of verbal imagery was determined by his responses to pictures of familiar objects. The proportion of verbal imagery to concrete imagery was determined by the relative frequency of each to a list of twenty words, presented orally, which were later to appear in some of the problems.

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[1] Seashore, C. E. Elementary Experiments in Psychology pp. 110 ff.

Sitting I, during which problems were given, was not held until at least a week had expired, in order that specific recollections of the results of the imagery tests would not intrude themselves when similar or identical stimulus words appeared in the presentation of the problems. The kymographic record in this sitting included (a) the time of the thinking in fifths of a second and (b) a record of the movements made by the subject during the thinking. The description of these was made in code by the experimenter on the kymograph key. Five problems were solved by each subject in each sitting.

Sitting II was similar to Sitting I with the exception that the subject was given the added instructions to press the key on the arm of his chair whenever he was conscious of the presence of imagery, releasing it when the imagery disappeared. The kymographic record, therefore, included (a) the time of the thinking in fifths of a second, (b) a description of the subject's movements made by the experimenter, and (c) the presence and absence of imagery occurring throughout, as recorded by the subject.

In Sitting III the attempt was made to determine more exactly the amount of movement made by the subject. The experimenter, therefore, pressed her key whenever she observed any movement made by the subject, releasing it when the movement disappeared. The subject was asked to react in the same way as in Sitting II. The kymographic record, therefore, showed the simultaneous record of (a) the time in fifths of a second, (b) the presence and absence of movement, and (c) the presence and absence of imagery.

Throughout Sitting IV various distractions; visual, auditory, verbal and hand-motor, were introduced during the thinking in order to learn, if possible, the connection existing between imagery and movement. Each kind of distraction was introduced during the solving of a problem which was likely to require imagery of the same sense field. Kymographic records were made by the experimenter of the nature and degree of the effect produced by the distraction.

Finally, Sitting V was given in the laboratory of the Neurological Department of the School of Physicians and Surgeons. The subject was asked to solve certain problems while records of his respiration, both thoracic and abdominal, the volume changes of his arm, the horizontal and vertical movements of his larynx and the movements of his tongue were being simultaneously made upon the kymograph. Four subjects only were used during this sitting, twelve problems in all being solved.

CHAPTER III

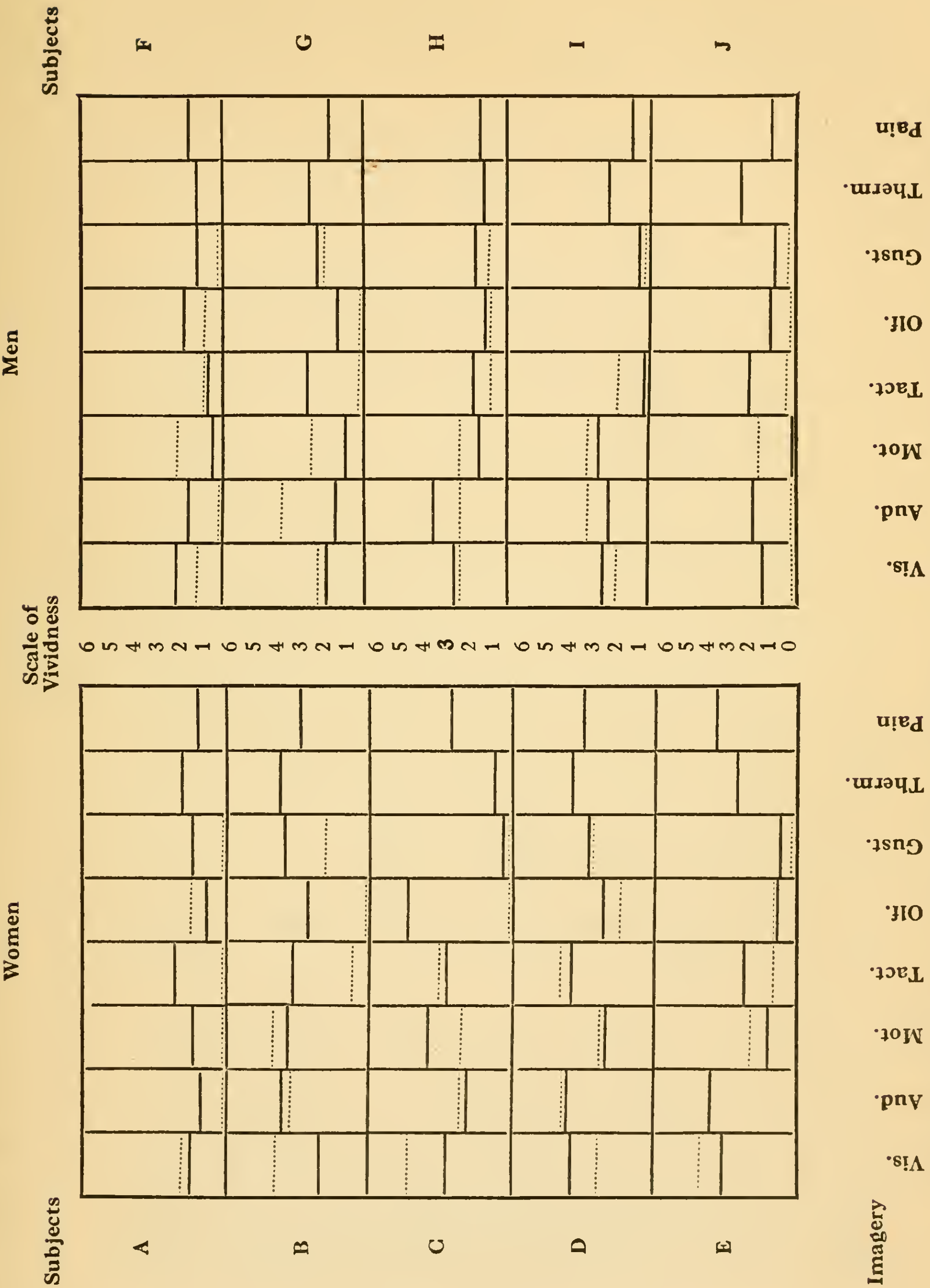
1.

INDIVIDUAL DIFFERENCES IN IMAGERY

Test 1. Seashore's original questionnaire was somewhat modified to secure certain desired results. It was made shorter by omitting all but three specific examples for each topic under each kind of imagery. The scale of five degrees of vividness was increased to six in order to eliminate a middle class into which the majority of images could be grouped. Moreover, for each kind of imagery, with the exception of those of temperature and pain, the subject was asked to "construct" an image, such as: a visual image of a bouquet of nasturtiums and pansies in a brass bowl, an auditory image of water dropping onto a piece of velvet, etc. A numerical estimate of the degree of vividness of each of these imaginary images was required, as in the case of the other images called for in the questionnaire.

The following diagrams, Fig. II, show the average degree of vividness with which each subject was able to summon each kind of imagery. It is apparent from these results that every subject could voluntarily call to mind at least one image of each sense field, with the sole exception of Subject I who was unable to summon any olfactory image. With this exception the range of imagery for all subjects included all the sense fields. In spite of this ability, a study of the separate reactions shows that Subjects D and H were the only ones able to summon every image called for in the questionnaire. The other subjects could not always call to mind images of familiar sensory experiences. One subject, J, was unable to summon twenty-seven such images. This inability to revive familiar sensory experiences may be due to the nature of the stimulus which was in each case visual verbal, thename of the senseexperience. In each instance, however, the subject was "thinking about" the experience, realizing it to be familiar, without being able to reinstate it, though he could reinstate others of the same sense field.

A glance at these curves also shows a noticeable sex difference, the women reporting more vivid imagery of every kind



Individual Differences in Mental Imagery—(Dotted line for vividness of imaginary image) than the men.[1] The difference is made clear in the following table, Table I, where the average degree of vividness of each kind of imagery is compared.

TABLE I

Sex		Vis.	Aud.	Mot.	Tact.	Olf.	Gust.	Therm.	Pain
M.	Av.	1.7	1.5	.9	1.3	.8	.9	1.4	1.3
	A. D.	.3	.5	.5	.6	.4	.5	.4	.4
F.	Av.	2.5	2.5	2.	2.8	1.3	1.5	2.2	2.6
	A. D.	.8	1.2	1.2	.6	.9	1.2	1.2	.9

In spite of the large average deviations for many of the scores, there is very little overlapping in the degree of vividness in imagery for the sexes, as only one woman, Subject A, had the majority of her averages as low as those for the men, while no man had a majority of averages as high as those of the women.

All the subjects could construct at least one imaginary image. Eight constructed at least four. The gustatory imaginary image, (to imagine the taste of chicken broth flavored with mint) seemed to offer the greatest difficulty, only four subjects being able to construct it. One of these gustatory images, however, was described by the subject as "clear and vivid rather than vague and dim." Indeed every subject summoned at least one imaginary image which was more vivid than his average for that kind of image. In fact, the majority of the imaginary images, twenty-three of the forty described, were more vivid than the average of that kind of image for that subject.

Every subject later reported the presence of at least three imaginary images in the thinking out of his problems. Seventy-eight such images were described, sixteen of which were purely visual, the rest combining various kinds of images. One subject, Subject D, described as many as nineteen of these imaginary images.

Test II. The individual's type of imagery was taken in this investigation to mean the kind of imagery most frequently used by that individual.[2] Assuming that frequency in use implied ease and readiness in association, a list of twenty words[1] was read to the subject who was requested to write down the kind of imagery which first came to mind when each word was perceived. The results of this are given in Table II.

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[1] Galton, F. Inquiries into Human Faculty, p. 99 Armstrong, A. C. and Judd, C. H. The Imagery of American Students, Psych. Rev. 1. pp. 496-505. French F. C. Mental Imagery in Students, Psych. Rev. IX. pp. 40-56. These suggest similar sex differences.

[2] Seashore, C. E. Elementary Experiments in Psychology, p. 114, and Feuchtwanger, A. Versuche ueber Vorstellungs-Typen. Zsch. f. Psych. 1911, LVIII. p. 162, emphasized this criterion for determining type of imagery.

From the results in column I it is clear that in response to an auditory verbal stimulus most of the subjects showed themselves to be of the visual type.

Test III. In order to determine whether the type of imagery depended upon the nature of the stimulus, a second set of twenty stimuli, cards upon which were pasted outline sketches of familiar objects, was presented to each subject. These results are given in column 2, Table II. With these visual concrete stimuli, verbal elements came first to mind in the case of every subject, so that the type for each was verbal. From these results it seems apparent that the type of imagery possessed by an individual depends upon the nature of the stimulus.[2]

If this conclusion be true, the types determined by Test II should coincide with the "actual" type of each subject: that kind of imagery used most frequently by each subject in the solving of his problems, which were themselves responses made to auditory verbal stimuli. These results are also shown in Table II. Visual images predominated in the solving of the majority of problems for all subjects. Consequently those subjects which were found to have been visual in type by Test II remained so. Subjects B, D and F, however, used verbal imagery in thinking as frequently as they resorted to visual imagery. But Subjects G and H, who were verbal in type by Test II, showed themselves to be of a visual type in actual thinking. A test such as Test II cannot, therefore, adequately determine the type of imagery which an individual will actually use in thinking, even when responding to the same kind of a stimulus.

The twenty stimulus words of Test II were words which appeared later in the statement of the problems, thus they were presented again orally to the subject as stimuli. These words appeared in the statement of eighty-one problems

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[1] See Appendix p. 95.

[2] Similar results were noted by Colvin, S. S. Methods of Determining Ideational Types, Psych. Bull. 1909, VI. p. 235; by Kakise, W. A. Preliminary Experimental Study of the Conscious Concomitants of Understanding, Am. J. of Psych. 1911, XXII. p. 63, and by Fernald, M. R. A Diagnosis of Mental Imagery, Psych. Rev. Mon.; 1912, XIV. No. 58. p. 98.

TABLE II

Subj.	Test II	Test III	"Actual" Type	"Supposed" Type
A	Vis.	Verb. (mot.)	Vis.	Vis.
B	Verb. (aud. mot.)	Verb. (aud. mot.)	Vis. & Verb. (aud. mot.)	Verb. (aud. mot.)
C	Vis.	Verb. (aud. mot.)	Vis.	Verb. (aud. mot.)
D	Vis.	Verb. (aud. mot.)	Vis. & Verb. (aud. mot.)	Vis.
E	Vis.	Verb. (aud. mot.)	Vis.	Vis.
F	Vis.	Verb. (aud.) (mot.)	Vis. & Verb. (aud. mot.)	Vis.
G	Verb. (aud.)	Verb. (aud.)	Vis.	Verb. (vis.)
H	Verb. (aud. vis.)	Verb. (aud. mot. vis.)	Vis.	Aud.
I	Vis.	Verb. (aud. mot.)	Vis.	Mot.
J	Vis.	Verb. (aud. vis.)	Vis.	Aud.

which were solved by the various subjects. In twenty-three of these instances the subjects did not report any imagery called to mind by these particular words. In fifty-eight instances, however, some imagery was described, of which thirty-three images, or 56.8 per cent, were the same kind of images as those aroused by the same stimulus word in Test II. It is possible, therefore, that a test such as Test II may indicate the kind of imagery which will immediately succeed a certain specific stimulus, but that it will not necessarily indicate the type of imagery which will predominate in an extended mental process.

After having taken these three tests, each subject was asked to state what he supposed to be his type of imagery. The responses to this inquiry are also given in Table II. Only half of the subjects showed in their thinking the dominant kind of imagery which they supposed their type to be. Again, only half of the subjects gave as their supposed type that which was disclosed by the results of Test II., where auditory verbal stimuli were presented. Moreover, only two subjects supposed their type to be that which, according to Test III, was their customary association to visual concrete stimuli. Finally, degree of vividness of imagery could not have been the basis of the subject's judgment of his supposed type, for only in the cases of Subjects F, H, and I was there correspondence between the "supposed" type and maximum vividness in imagery. An estimate of one's own type of imagery is, therefore, not necessarily influenced by results gained from an analysis of one's own imagery by means of tests, nor does it necessarily anticipate the kind of imagery which will predominate in the solving of problems.

From the above evidence, slight though it be, the following conclusions seem justifiable:

1. An individual may think about a familiar sensory experience and still not be able to voluntarily call to mind an image of it, although he may be able to summon other images in the same sense field.

2. Mental images for men are less vivid than for women.

3. Imaginary images can be voluntarily constructed and they are apt to be more vivid than the individual's average image in the same sense field.

4. The kind of imagery which first comes to mind varies with the kind of stimulus which arouses it and with the

specific characteristics of each separate stimulus. It is, therefore, difficult to discover in individuals a distinct type of imagery.[1]

5. An individual's estimate of his own type of imagery does not necessarily describe the kind of imagery which can be voluntarily summoned most vividly, nor does it anticipate the kind of imagery which will predominate in his solving of simple problems.

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[1] Similar results have been noted by Colvin, S. S. Op. cit. p. 235, and by Fernald, M. R. Op. cit. p. 130.

CHAPTER III.

SITTING I.

The main purpose of this sitting was to familiarize the subject with the general procedure of the experiment. The following instructions were given to the subject: "This is an experiment in thought. I am going to ask you to solve a problem which I hope will be solved in some way which will be new to you. I will, therefore, ask you what you would do if you were in a certain situation which I think will be a novel one for you, or else I will ask for your opinion about some matter which I think you have not considered before. The problem will be simply stated so that you will not need to ask questions about it. As soon as you hear the problem, will you think it over until you reach a conclusion which seems new to you. Then you may signal to me as soon as you have reached this point."

The experimenter pressed her key when she started to give the problem, released it when she finished, described the subject's movements by her key, making use of the code,[1] and pressed the key again when she received the signal from the subject that he had reached a new conclusion. This record was made on the kymograph with a simultaneous record of the time in fifths of a second. The answers of the subject to the required questions[2] were recorded verbatim after each problem was solved. Five problems were solved by each of the ten subjects.

A study of the results of this sitting shows that the gross bodily behavior of each individual represented a characteristic mode of adaptation which he adopted toward all his problems. Subject D, for instance, after having heard the problem, invariable raised her right arm to the arm of her chair and rested her chin on it. Subject E, on the contrary, looked downward, raised her right hand to her chin, rubbing her chin almost continuously throughout her thinking. Subject C, however, looked downward before she said she was ready for the problem and remained comparatively motionless throughout. In a similar way, Subject F leaned his head on his right hand supported by the arm of his chair and fixed his gaze on some spot before he signalled that he was ready for the problem. He then maintained this position, with slight change, throughout his thinking. In one instance, however, when he was not in this position at the time the problem was given, he adopted this attitude as soon as he had heard it. This gross bodily behavior was so invariably adopted by each individual that it seemed to have no bearing on the solving of the various problems, but was simply a bodily adjustment for the better concentration of attention.

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[1] See Appendix, p. 89.

[2] See above p. 17.

Aside from these movements of adaptation, more minute movements which appeared more irregularly were observed by the experimenter, such as eye and lip movements, smiles, frowns, and nods. These movements seemed to be more relevant to the solving of each specific problem, as there was a certain degree of correspondence between them and the thought and imagery which were described in the subject's retrospections.

Another kind of movement was noted by the experimenter which seemed to have no noticeable connection with the thought going on at the time and which apparently played no part in adapting the individual for better concentration of attention. These movements were those of the larger muscles, such as: random movements of hands and feet, scratching the head, stroking the hair, etc. These have been termed "doubtful movements," as their connection with the thinking was not apparent.

A distribution of the different kinds of movement is shown in Table III where the reactions of all the subjects to all of their problems are divided into five-second periods, and the average number of each kind of movement appearing in each period is given.

The results given in Table III show that in general the number of movements tended to diminish as the thought became prolonged. The more minute movements which seemed to be relevant to the thinking were those most frequently resorted to. Doubtful movements were less frequent in their appearance than movements of adaptation and they failed to persist throughout the thinking as did the relevant movements and those of adaptation.

In order to bring to light more clearly the relation of those different kinds of movement to the development of thought,

TABLE III

5 sec. Periods	No. of Reactions	Av. No. of M'v'ts.	Ave. No. of Adapt. M'v'ts.	Ave. No. of Doubt. M'v'ts.	Ave. No. of Rel. M'v'ts
1	50	1.9	.58	.40	.92
2	49	1.6	.34	.43	.79
3	41	1.5	.39	.29	.90
4	36	1.1	.33	.27	.55
5	32	1.09	.28	.20	.56
6	27	1	.47	.07	.51
7	21	1.1	.47	.33	.33
8	20	1.1	.45	.25	.50
9	19	.7	.21	.26	.31
10	18	.9	.33	.16	.44
11	14	1.07	.21	.14	.71
12	13	1.1	.38	.23	.53
13	11	.5	.09	.09	.36
14	9	.8	.33	.11	.44
15	6	1.	.16	.33	.50
16	5	.4	.40		
17	4	.2			.25
18	4	.5	.25	.25	
19	4	.7	.25		.50
20	4	.5	.50		
21	4	1.	.75		.25
22	4	1.7	.75		1.
23	1				
24	1	1.	1.		

Table IV is given below in which the reaction time of each problem is divided into four parts[1] and the extent of the different kinds of movement in each quarter is shown.

TABLE IV

Quarters of Reaction	M'v'ts. of Adaptation	Doubtful Movements	Relevant Movements	Total Number of Movements
I	28.6%	26.2%	45.2%	164
II	34.8	19.6	45.6	132
III	26.9	17.3	55.8	104
IV	29.7	18.	52.3	94

From these results it is apparent that movement decreased as thinking progressed. Relevant movements were throughout most conspicuous, especially in the second half of the thinking where they were more numerous than both of the other kinds combined.

A closer scrutiny of the kymographic records showed that, in spite of the greater number of movements found in the first quarter, forty-three of the fifty reactions showed a perceptible pause immediately after the presentation of the problem where no movements were observed by the experimenter.[1] The average length of this pause was 2.7 seconds, and since the average reaction time for solving the problems was 34.4 seconds, making the average length of the quarters only 8.5 seconds, this initial pause was an obvious one.[2]

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[1] This reaction time does not include that of the presentation of the problem.

During this pause it is possible that no movements at all were made by the subject, or that there were movements which could not be observed by the experimenter. In thirteen of the forty-three reactions in which this pause appeared, visual images were reported to have followed the preception of the problem; in eight, verbal images; in three, both visual and verbal; and in four, visual with other kinds of concrete imagery. In ten of these reactions the subjects reported that they "thought about" various things but they failed to describe their states of mind any further. In five reactions, however, the mental states immediately following the presentation of the problem were definitely described as imageless: the recollection of a preceding problem as a "total not split up," a "feeling of amusement," a "feeling of uncertainty," a "search for the meaning," and an "Einstellung towards the problem."

In the seven reactions in which this initial pause was not apparent, visual imagery was reported to have followed the perception of the problem once, while no accompanying eye-movement was observed by the experimenter. Both verbal and visual imagery appeared once, when accompanying lip movements were detected by the experimenter. In two reactions the subjects did not describe their first states of mind, and in the remaining three reactions imagery was reported absent, in its stead being a "feeling of novelty," of "being at a loss," and inner speech. From this conflicting evidence it is, therefore, impossible to conclude whether or not, during this initial pause, movements, too slight to be observed, accompanied the mental states which were experienced.

Another pause which was found to be characteristic of a large number of reactions, forty-one, immediately preceded the final signal given by the subject. The average length of this pause was 3.2 seconds, slightly longer than the initial pause. This pause is significant as the subject was told to signal to the experimenter as soon as some novel solution came to mind. The truly productive phase of thinking, therefore, very likely preceded this final signal and was apparently usually characterized by a cessation of noticeable movements.[1]

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[1] No pause less than two-fifths of a second was included.

[2] A similar pause was present in forty-one of forty-nine reactions in which the subjects failed to reach novel conclusions.

In describing the novel part of their thinking in these forty-one reactions, the subjects reported the presence of visual images in ten instances, verbal images in seven, both visual and verbal in twelve, a combination of concrete imagery in two, and auditory imagery in one. The novel part of four reactions the subjects were unable to describe. Five solutions, however, were definitely described as imageless: two were "flashes," the others "a consciousness of forward movement," "non-sensory but clear," "no terms at all, merely a feeling of plausibility."[2]

In the nine reactions in which this final pause was not apparent two novel solutions were described as verbal, the experimenter detecting accompanying lip movements in one instance. Two were described as containing both verbal and visual imagery, one of which showed accompanying eye movements. Three novel solutions the subjects were unable to describe, one of which showed the presence of lip movements. Finally, two were characterized as "ideas," neither of which were accompanied by "relevant" movements which could be detected. Again evidence is too conflicting to be able to state the likelihood of the subject to make incipient movements during this final pause when he apparently "stopped to think."

Imagery was reported to have been present in every one of the fifty reactions. In twenty-one reactions it was said to have been present throughout the thinking, while in the remaining twenty-nine reactions it came and went. Visual imagery alone was reported present in ten solutions, while verbal imagery appeared alone in but two solutions. The latter was usually, in thirty-six of the fifty reactions, accompanied by concrete imagery. Visual imagery, therefore, seemed to have been more important to the solving of these problems than did verbal imagery.

Many states of consciousness, other than those previously described, were definitely reported to have possessed no imagery. In four instances, periods of "blankness" were decribed, also alluded to as "gaps in the progress" and "periods of waiting for something to happen." The remembrance of an event was once described as "knowing," independent of imagery. One subject reported that though she could usually summon images of concrete things, in the thinking out of her problem she merely "thought of cream, cereal, and lots of staple products." Another subject said that an idea, though distinct, was not necessarily related to imagery, as it came before the images. The acceptance of an alternative was described by another as a kind of feeling, rather than sensory. A "feeling of direction" was also differentiated from imagery. Finally, some thinking was described as abstract: "the ruling out of soldiers was abstract, not in terms of imagery." In no case was the term "Bewusstseinsalage" used by any subject and in but one instance was the term "imageless thought" resorted to.[1] The importance of these imageless states to thinking is difficult to determine from the above evidence.

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[1] This pause was not as conspicuous in reactions in which the subjects failed to reach novel conclusions. Twenty-one of forty-nine reactions failed to show this pause.

[2] Cf. Woodworth, R. S., Imageless Thought. J. of Phil. Psych. etc. 1906 III. p. 706.

The following table, Table V, shows the amount of the different kinds of movement characterizing the instances of thinking, grouped according to their length of reaction time.

TABLE V

Reaction time	No. of Reactions	Av. No. M'v'ts.	Av. No. Adapt. M'v'ts.	Av. No. Doubt. M'v'ts.	Av. No. Rel. M'v'ts.
-10 sec.	9	2.7	.55	.22	2.1
10-20	9	3.5	1.1	1.	3.5
20-30	11	7.5	1.4	1.8	4.2
30-40	2	10.5	2.	.5	8.
40-50	5	8.2	3.4	3.4	1.4
50-60	3	11.3	5.3	1.6	4.3
60-70	5	20.2	5.4	3.6	11.2
70-80	2	13.5	6.	6.	1.5
80-90					
90-100					
100-110	3	27.	9.6	7.	11.6
110-120	1	29.	12.	1.	11.

These results show that the number of movements of adaptation which were resorted to tended to vary in proportion to the length of reaction time. Relevant and doubtful movements, on the other hand, failed to show such a steady increase. The frequency of the doubtful movements resembled that of the movements of adaptation more than that of the relevant movements. The latter, however, tended to be more numerous throughout than both of the other kinds of movement.

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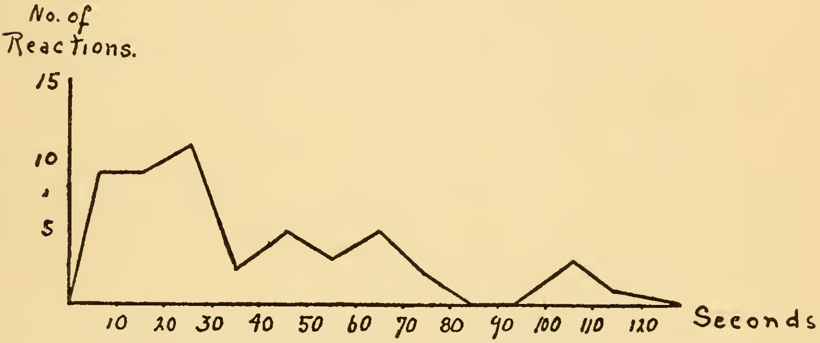
[1] Subject I; his consciousness of "tablets" he reported to have been "like imageless thought." (Problem 12)

When the distribution of the reactions is presented in graphic form, giving the frequency of reactions for each division in length of time required for thinking, Fig. III, the trimodal appearance of the curve makes it possible to describe some of the reactions as "rapid" (less than thirty seconds in length), "moderate" (between thirty and eighty seconds long), and "slow" (over 100 seconds long). The majority of reactions, twenty-nine, are shown to have been rapid.

FIG. III



FIFTY THOUGHT REACTIONS
(Arranged according to time required for thinking.)

A comparison of these three classes of reactions, in respect to the average number of the different kinds of movement found in each, is shown in the following table, Table VI.

TABLE VI

Kinds of Reac.	No. of Reac.	Av. Time of Reac.	Av. No. of M'v'ts.	Av. No. of Adapt. M'v'ts.	Av. No. of Doubt. M'v'ts.	Av. No. of Relevant M'v'ts.
Rapid	29	16.1 sec.	5.5	1.06	1.06	3.3
Moderate	17	56.1	13.1	4.4	3.1	5.5
Slow	4	111.3	27.5	10.5	5.	12.

From these results it is apparent that the thinking, whether rapid or slow, was characterized more by minute relevant movements than by movements of adaptation or of doubtful character; movements of adaptation, however, varied more concomitantly with the length of the thought process. In moderate and slow thinking, therefore, the subjects repeatedly adapted themselves for better concentration of attention and frequently resorted to movements of the limbs, the relations of which to the thinking were doubtful.

As regards imagery, twelve of the twenty-one reactions in which imagery was reported present throughout the thinking were instances of rapid thinking. Only one case of slow thinking showed this characteristic. Moreover, eight of the ten reactions in which visual imagery alone was present were quick reactions. No slow reactions contained merely visual imagery, for in every instance verbal imagery was also present. On the other hand, five of the seven reactions, in which the actually novel part of the thinking was described as definitely imageless, were instances of rapid thinking, and all of the reactions in which the subjects were unable to describe this part of their thinking were also quick reactions. Consequently, one may conclude that rapid thinking may be characterized by a predominance of concrete imagery or by states of mind lacking in imagery of any sort.

This classification of reactions into the rapid, the moderate, and the slow brought to light individual differences in the subjects. All of the reactions of A, C and H were rapid, none of the reactions of D and E were rapid, and none of the reactions of B, F, G, and J were slow.

In spite of the fact that this was merely an introductory sitting, its results, which are not contradicted by those of later sittings, seem to justify the following conclusions:

I. In thinking out problems individuals take certain characteristic bodily attitudes of adaptation for the better concentration of attention.

II. Movements are less apparent as thought develops.

III. In thinking, the most frequent kind of movement is of a minute sort: movements of eyes and lips, scowls and nods, which seem to be relevant to the changing content of consciousness.

IV. Immediately following the presentation of the problem, and also just preceding the termination of the thinking when some noval conclusion has presented itself, the thinker usually becomes noticeably quiet.

V. Either concrete visual imagery or verbal imagery may be the only kind of imagery present in the solving of a problem or in the actual production of a new conclusion. Neither kind of imagery alone, however, characterizes prolonged thinking.

VI. Imagery in thinking usually comes and goes, although it is frequently present throughout the thinking, especially in quick reactions.

VII. Conscious states may be experienced which cannot be described in terms of concrete or verbal imagery. These may characterize the actual production of a new conclusion, especially in instances of rapid thinking.

VIII. Rapid thinking is characterized by either an abundance of concrete imagery, or by the prevalence of conscious states imageless in character.

CHAPTER IV.

SITTING II.

In this sitting the following instructions were given to the subject: "I am going to ask you to solve problems in the same way that you did before, with the exception that you are to press the key on the arm of your chair whenever you are conscious of the presence of images during your thinking, releasing the key when the imagery disappears. I will ask you to do this while I am giving you the problem if you happen to have imagery during that period."

It was the purpose of the experimenter to secure primarily a quantitative measure of the amount of imagery found in thinking. The kymograph was, therefore, arranged to record simultaneously the time in fifths of a second, the experimenter's observations of movements as in Sitting I, and the reactions of the subject's key showing the presence and absence of imagery.[1] A verbatim record of each subject's answers to the required questions for each of the five problems was taken as in Sitting I.

There is no doubt but that pressing the key to indicate the presence of imagery offered some distraction to the subject. Seven problems of Sitting I were given in Sitting II to different subjects. Six of these had a longer average reaction in the second sitting than in the first. But since seven of the ten subjects kept the same general record for speed which they had in Sitting I, and since only one reported the presence of distraction after the first two or three trials, it seems apparent that the subjects adapted themselves to the situation very readily.[2] In fact, it seemed to have become a habit for two who, in Sitting IV, unconsciously reached for the key when they were conscious of imagery.

The following table, Table VII, shows the average number of each kind of movement and the average time of imagery in seconds found in every five-second period of all the reactions of this sitting.

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[1] For typical kymographic records, See Fig. VIII, Appendix p. 96.

[2] Subjects A, C, and D were given extra sittings in which they practiced solving problems with this use of their key. They all reported that although the act never became automatic, it could be used without interference.

TABLE VII

5 sec. Periods	No. of Reactions	M'v'ts.	Av. No. of			Av. Time of Imagery sec.
			Adapt. M'v'ts.	Doubt. M'v'ts.	Rel. M'v'ts.	
1	50	1.8	.58	.20	1.02	2.20
2	49	1.1	.55	.31	.40	2.89
3	45	.9	.39	.13	.44	2.96
4	43	1.2	.55	.15	.67	2.89
5	40	.9	.62	.22	.62	2.75
6	35	1.1	.35	.26	.52	2.82
7	34	.9	.15	.34	.53	3.50
8	32	.9	.34	.28	.46	3.12
9	28	.9	.47	.17	.57	3.03
10	23	.9	.13	.26	.59	2.68
11	22	.7	.09	.42	.27	2.76
12	21	1.3	.61	.22	.72	3.68
13	18	.8	.37	.06	.54	3.28
14	16	1.	.24	.18	.54	2.90
15	11	1.4	.36	.27	.81	2.94
16	11	.8	.18	.27	.36	2.69
17	9	1.1	.11	.55	.44	2.66
18	9	.8	.11	.22	.55	2.26
19	9	1.1	.22	.66	.55	2.08
20	9	.7	.22	.22	.33	2.48
21	9	.7	.11	.55	.11	2.35
22	7	.8	.28	.28	.28	1.88
23	5	1.2	.40	.30	.60	2.88
24	5	1.4	.40		1.	1.00
25	5	.2	.20			1.20
26	3	1.3			1.33	1.93
27	2	1.			1.	2.50
28	2	3.	1.	1.	1.	2.50
29	1	2.	1.		1.	.60
30	1					
31	1					
32	1				1.	
33	1	1.			1.	2.
34	1	2.	1.		1.	
35	1	2.	1.			
36	1					
37	1					
38	1	1.		1.		
39	1					
40	1	1.			1.	
41	1	1.		1.		

The results of this table show characteristics similar to those given in Table III of Sitting I. In general, the number of movements tended to decrease as the thought became prolonged. Relevant movements were those most frequently resorted to. Again, the doubtful movements were least frequent, failing to appear in the latter part of long periods of thinking, where movements of adaptation and relevant movements continued to appear.

The above results also show that imagery as well was not always present in the latter part of the longer periods of thinking. It is noteworthy, moreover, that the amount of imagery was not greatest in the first part of the thinking, in spite of the fact that the kymographic records frequently showed the presence of imagery during the presentation of the problem. On the contrary, the amount of imagery tended to increase after the first few moments of thought.

Table VIII, which follows, gives the extent of each kind of movement in terms of the percentage of the total number of movements recorded for each quarter of all the reactions, as in Sitting I, as well as the percentage of the total time of that quarter in which imagery was present.

TABLE VIII

Quarters of Reactions	Movements of Adaptation	Doubtful Movements	Relevant Movements	Total No. Movements	Amt. of Imagery
I	39%	14.2%	46.8%	182	46.8%
II	34.6	14.6	50.8	150	53.2
III	21.1	27.8	51.1	151	56.
IV	25.	30.	45.	140	55.6
				Total 623	Av. 52.9

These results agree closely with those of Table IV, Sitting I, and with those of the preceding table. Movements in general tended to decrease as the thinking progressed. Moreover, relevant movements were those most frequently present as before and they remained the most prominent kind of movement in each quarter of the thinking. This sitting, however, showed an increase in the number of doubtful movements, especially in the second half of the thinking, as compared with those recorded in Sitting I.

As in Table VII, imagery is found to have increased in amount after the first part of thinking. Its development was more closely parallelled by the changes in relevant movements than in any other kind of movement.

Again, as in Sitting I, in spite of the great number of movements in the first quarter, a larger majority of the reactions, forty-five, showed the presence of a pause following the presentation of the problem. The average length of this pause was 3.5 seconds, slightly longer than the initial pause of Sitting I. The average time for solving the problems of this sitting, however, was longer than that of the previous sitting, 55.8 seconds, probably due to the pressing of the key,[1] so that the length of this pause might be considered proportional to that of Sitting I.

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[1] See above p. 36.

In twenty-four of the forty-five reactions in which this pause appeared, the kymographic records showed that imagery, either concrete or verbal, accompanied the pause. In five of the remaining twenty-one reactions, where no imagery was recorded during this initial pause, states of consciousness which were definitely described as imageless followed the presentation of the problem. These were: a "feeling of recognition," a "feeling of being directed toward the ocean," a "feeling of being at a loss," the "thought that this question was related to the preceding one," and "the grouping of the problem as a whole," which was later followed by imagery.

In two of the five reactions where no initial pause was present the kymographic records showed that imagery followed the presentation of the problem. In one instance where visual and verbal images were described both eye and lip movements were detected by the experimenter. In the other instance, visual imagery was present, but it was described as fleeting, and no eye movements were noticeable. It is again difficult to decide, as in Sitting I, whether this pause is due to a lack of movement or to the presence of movements too fine to be detected by an onlooker.

The pause which preceded the subject's final signal was found to have characterized a large proportion of the reactions, thirty-nine, in this sitting as in Sitting I. The average length of this final pause was 4.5 seconds. Mental imagery, either concrete or verbal, was present during this pause in twenty-seven of these reactions, according to the kymographic records. Of the twelve remaining reactions, some of the conscious states which were reported as imageless were described in the following ways: "abstract thinking, experiencing relations which couldn't be analyzed," "proof" which followed the awareness of a possible solution, "awareness of similarity, of limitations, and of differences," and the "thought that the solution was good enough as long as no other idea was coming up."

Of the eleven reactions which showed no final pause, seven had imagery preceding the giving of the final signal, four of these had verbal imagery, in all of which cases lip movements were detected. Visual imagery was reported in three instances, but no accompanying eye movements were detected by the experimenter. The remaining reactions which were definitely imageless in this last part of the thinking, as shown by the kymographic records, were decribed as "release in tension," "the feeling that these points will do," and an analysis "to see if this is the best solution." Again, with evidence so conflicting, it is difficult to explain the presence of this final pause.

Some imagery was described in the retrospections of all of the fifty reactions with the exception of three,[1] those of Subject A who was herself surprised at the fact.[2]

In sixteen of the remaining forty-seven reactions the kymographic records showed the presence of imagery throughout the complete thought process. Two of these reactions contained merely visual images. Verbal imagery alone was present throughout but one reaction, being usually, in eleven reactions, accompanied by concrete images.

In nine of the forty-seven reactions which contained imagery the subjects reported that merely concrete imagery was present. It is noteworthy that eight of these nine reactions were instances of rapid thinking. One reaction alone was said to have contained only verbal imagery; this being usually, in thirty-seven reactions, accompanied by concrete images. In the actually novel part of thinking, on the other hand, verbal imagery predominated. It was present alone in eighteen solutions, while concrete imagery alone appeared fourteen times. Eleven solutions presented themselves in terms of both concrete and verbal imagery, while seven solutions could not be described in terms of either.

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[1] Cf. Lummis, B. A. A Study of Thought Processes, p. 76.

[2] Problem I. 8. What do you think is the best way to teach geography to children? Ans.: I was at first at a loss, for I have no interest in geography. I knew I had talked about teaching geography in an objective way before. I had a feeling of knowing I remembered it. I turned to my personal experiences after I found the objective method was not new. Then I thought of telling them about my travels. I accepted this as something new. No imagery. Time 10.4 seconds.

Problem I. 9. During what years is it the best time to teach geography to children? Ans.: I thought first that this problem was connected with the preceding one. I did not know how to answer it. Then I thought it was better to begin with little children. It came so quickly, I don't know why I said this, perhaps because I had decided before to tell them about my traveling. No imagery. Time 6.6 seconds.

Problem II. 8. What would be the probable consequences if the sea could be owned by individuals as the land is? Ans.: I had a tendency of being directed toward the ocean between Europe and America. I wondered how any one would use it. Then I thought of fishing, but this wouldn't have serious consequences. It would be the same between individuals as between governments now. The problem would arise in regard to traffic, getting from one place to another. This problem would be solved in the same way that it has been for the railroads. I was satisfied that this relationship was new. Thinking was abstract, nothing specific. I had an experience of relations that couldn't be analyzed. No imagery. Time 36 seconds.

A study of the correspondence of movement and imagery as shown by the kymographic records brought to light the following facts: the majority of periods in which imagery was present (57.7 per cent) were accompanied by movements; 41.3 per cent of this movement was relevant, 38 per cent doubtful, while the remaining 20.7 per cent of the movements were for purposes of adaptation. When the periods of verbal imagery could be differentiated from those of concrete imagery by comparing the kymographic records with the subject's retrospections, 47 per cent of these periods were accompanied by noticeable lip movements. When the periods of visual imagery were singled out, 37.2 per cent were found to have been accompanied by perceptible eye movements. When of these the memory images could be differentiated from the imagination images,[1] more memory images were accompanied by eye movements (48.1 per cent) than was the case with the imagination images (14.3 per cent).[2]

Throughout the fifty reactions of this sitting there were 147 periods which the kymographic records showed to be imageless, breaks in the flow of imagery. During many of these (42.1 per cent) the subjects reported a feeling of progress. These were times when they "thought," they "stopped to analyze," or they "went over the entire field." Other imageless periods (34.6 per cent) were described as not accompanied by such a feeling of progress, being passive rather than active. During these periods the subjects "felt blank," were "receptive," "waiting for something to come." The characteristics of the remaining 23.1 per cent of these imageless states were not described by the subjects.

A study of the passive imageless states showed that the majority (64.7 per cent) were not accompanied by movement of any sort. Of the movements which did occur, 43.1 per cent were movements of the hands and feet, 31.3 per cent were lip and eye movements, and 25.4 per cent were those of bodily adaptation.

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[1] Images which were novel to the subjects.

[2] Perky, C. An Experimental Study of Imagination, Am. J. of Psych. 1913, XXI. p. 451. Martin, L. J. Die Projektions Methode u. d. Lokatization visuelles u. a. Vorstellungsbilder. Zsch. f. Psych. 1912, LXI. p. 407, and Clark, H., Visual Imagery and Attention. Am. J. of Psych. 1916, XXVII, p. 490, have noted the accompaniment of eye movements with visual memory images. The evidence about the relation between ocular movements and visual imagination images is conflicting.

The active imageless states, on the other hand, were usually accompanied by movement (72.6 per cent). Thirty-five per cent of these movements were those of the lips and eyes, while 10 per cent were hand and foot movements.

These imageless periods constituted practically half of the time given to thinking, the subjects being conscious of imagery only 52.9 per cent of the time. A detailed description of these states would be exceedingly difficult, not only because of their variability, but also because the subjects frequently were unable to describe them, even when they were keenly conscious of their existence.

The following table, Table IX, shows further characteristics of thinking similar to those noted in Table V, Sitting I.

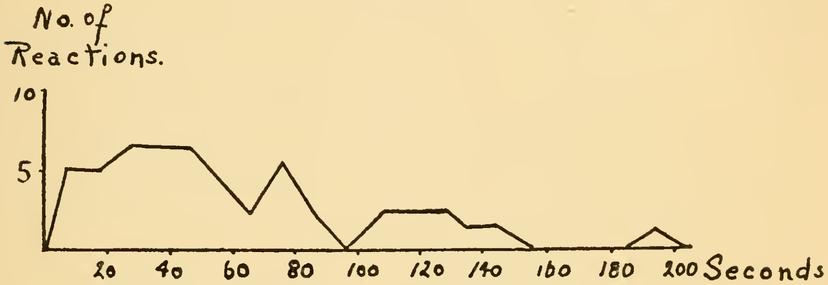
TABLE IX

Reac.	No. of		Av. No. of			Av. Time of
Time	Reactions	M'v'ts.	Adapt. M'v'ts.	Doubt. M'v'ts.	Rel. M'v'ts.	Imagery sec.
—10″	5	2.4	.6	.8	1.	2.2
10—20	5	5.8	.8	.6	4.4	12.8
20—30	6	4.3	1.6	.2	3.4	14.9
30—40	6	7.8	2.1	1.1	4.5	25.2
40—50	6	12.1	5.3	.6	6.3	21.4
50—60	4	13.5	4.7	6.	2.7	33.6
60—70	2	6.5	2.5	2.5	1.5	16.1
70—80	5	14.6	4.6	2.6	7.4	43.3
80—90	2	16.	6.5	6.5	3.	73.9
90—100						
100—110	2	20.	8.	9.	3.	37.4
110—120	2	25.	10.	3.	12.	23.5
120—130	2	41.	8.5	7.5	25.	7.6
130—140	1	35.	6.	3.	26.	2.2
140—150	1	15.	5.		10.	140.
190—200	1	36.	11.	8.	17.	4.6

As before, the average number of each kind of movement for each division in length of reaction time is shown, while the last column gives the average time of thinking during which imagery was present. The number of movements of adaptation, as in Sitting I, was proportional to the length of reaction time, while the relevant and doubtful movements failed to show such a steady increase. Again the relevant movements were more numerous than both the doubtful movements and the movements of adaptation. The frequency of the doubtful movements resembled that of the movements of adaptation, although there was no correspondence between the variabilities of each. As before, the amount of imagery did not particularly characterize the first few seconds in thinking, nor was it increasingly prominent in the longer reactions.

The following graph, Fig. IV, shows the distribution of all the reactions of this sitting according to the length of time required for thinking.

FIG. IV



FIFTY THOUGHT REACTIONS
(Arranged according to time required for thinking)

As in Sitting I the distribution of these reactions makes it possible to classify them as "rapid," (less than 60 seconds,) "moderate" (between 60 and 100 seconds,) and "slow" (over 100 seconds in length). Here again, as in Sitting I, the majority of reactions, thirty-two, are found to have been rapid.

TABLE X

Kind of Reaction	No.	Av. time sec.	Av. no. M'v'ts.	Adapt. M'v'ts.	Av. no. Doubt. M'v'ts.	Relevant M'v'ts.	Av. time Imagery sec.
Rapid	32	29.5	7.5	2.4	1.6	3.7	18.1
Moderate	9	72.7	13.1	4.5	3.4	5.1	44.
Slow	9	129.6	28.6	8.3	5.5	14.7	53.2

These results of Table X are similar to those of Table VI, Sitting I. Again the predominance of relevant movements, as compared with both doubtful movements and those of adaptation, is apparent. As already pointed out in Table IX, imagery is not conspicuous in either moderate or long reactions. There is, in this table, no noticeable similarity between the amount of imagery and the number of relevant movements as was apparent in Table VIII.

In spite of the fact that imagery is shown in the above tables not to have particularly characterized very rapid thinking, the majority of the kymographic records which showed the presence of imagery throughout the thinking, twelve of the sixteen, were quick reactions. Also, as in Sitting I, the majority of the reactions in which visual imagery was the only kind present, five of the six, were instances of rapid thinking. The slow reactions contained verbal imagery with the visual. On the other hand, the three reactions which were described as imageless belonged to this group of quick reactions; in fact, they were especially quick for the group, being 6, 10, and 36 seconds in length respectively. Again, as in Sitting I, of the majority of instances where the actual 1y novel part of the thinking was definitely described as imageless, four of the seven were quick reactions. It is therefore true, as before, that rapid thinking was either characterized by a great deal of imagery or by conscious states which could not be described in terms of imagery.

Some individual differences in rapidity of thinking were found in this sitting, as in Sitting I. Subjects A and H were quick in all of their reactions, D and J were slow in none, and none of the reactions of I were quick. Subject C lost her former record of always thinking rapidly, D and E showed themselves capable of rapid thinking, while B, F, and G, resorted to slow thinking but once.

Finally, the exact record of the time during which imagery was present, which was taken in this sitting, makes it possible to correlate thinking with imagery, giving the following results: the correlations of the fifty reactions in respect to amount of imagery and length of reaction time gave $r = .45$. Taking the 32 reactions which have been called "rapid," this correlation between amount of imagery and length of reaction time gave $r = .55$. With the 9 "moderate" reactions, this correlation was .34, while from the 9 "slow" reactions a correlation of —.15 was found.

These correlations indicate that the thinking in general was apt to have been accompanied by imagery: the faster the thinking, the more apparent the imagery, and, moreover, the slower the thinking the less apparent the imagery. As two-thirds of the 9 slow reactions showed a negative relation between imagery and movement and but one-third of the instances of moderate thinking showed this characteristic, the length of reaction time which would be likely to give a 0 correlation, and thus show a lack of relationship between the rate of thinking and imagery, lies between 85 and 106 seconds. These facts support the statements already made above.

The results of this sitting, as have been shown, have offered further evidence to support the conclusions which were drawn from the results of Sitting I. They also offer evidence upon which the following conclusions may be based:

I. A problem may be comprehended, thought out, and solved in terms which cannot be described as any kind of imagery.

II. Imagery tends to increase in amount as the thinking develops until the very last steps in thinking are reached, when it frequently is absent.

III. Imagery is seldom present continuously throughout the solving of a problem. On the contrary, it usually comes and goes, actually taking up little more than half of the time given to thinking.

IV. Periods of imagery are often accompanied by perceptible movements, the kind of movement being frequently relevant to the imagery described.

V. Imageless periods are more often described as active, being accompanied by feelings of progress, than as passive. Such states are physically as well as mentally active, while the passive states are more frequently mentally and physically passive.

VI. Rapid thinking is correlated more highly with imagery than are instances of more moderate thinking; while, after a certain point, the longer the thinking the less the amount of imagery experienced.

CHAPTER V.

SITTING III.

The results of Sitting II made it possible to determine the kind of movement which accompanied the periods in which imagery was present or absent, but they failed to show the length of time actually taken up by these movements. As this evidence was given in the case of the imagery but not of the movements, a complete correspondence between the two could not be determined. Accordingly, in Sitting III the subjects were given the same instructions as in Sitting II. The experimenter, however, instead of recording the kind of movement she observed, pressed her key as soon as she detected movement on the part of the subject and released it when the movement ceased. The kymographic record, therefore, showed the presence and absence of imagery, as indicated by the subject's key, together with the presence and absence of movement, as indicated by the experimenter's key, accompanied by the time record in fifths of a second. The experimenter also kept a verbatim record of the answers to the required questions of each subject for all five reactions, as in Sittings I and II.

The following table, Table XI, gives the average amount of movement and imagery in terms of seconds found in each five-second period of all reactions of this sitting.

The results given are very similar to those of Sittings I and II. In general, the number of movements tended to decrease as the thinking was prolonged. The relative lack of imagery at the start followed by a slight increase in amount as the thinking progressed, disappearing in the latter part of long reactions is again noticeable. Imagery is found to have been more often present than perceptible movements, the total time for the former being 1,593.8 seconds as compared with 1,139.4 seconds during which movement was perceptible. 52.8 per cent of the time taken by movement was accompanied by the presence of imagery, while 37.9 per cent of the time during which imagery was present was accompanied by noticeable movements. Movement and imagery were apt to be combined in the earlier rather than in the later parts of the thinking. The amount of time during which movement and imagery

TABLE XI

5 sec. Periods	Number of Reactions	Av. Time of		
		Movement	Imagery	Imagery & Movement Combined
		sec.	sec.	sec.
1	50	2.5	2.04	1.3
2	49	2.1	2.6	1.2
3	48	2.2	2.8	1.3
4	46	2.1	2.9	1.2
5	42	1.5	2.9	1.1
6	42	1.9	2.8	1.2
7	39	1.5	2.9	.8
8	36	1.6	2.6	1.1
9	28	1.6	3.02	1.4
10	24	1.1	3.6	.8
11	21	1.3	2.7	.7
12	21	1.4	2.4	1.09
13	19	1.02	3.	.6
14	18	1.02	3.03	.8
15	17	.7	2.6	.2
16	16	1.01	2.01	.5
17	13	.5	2.1	.5
18	13	1.2	2.2	.4
19	10	1.1	2.5	.4
20	10	1.02	2.4	.3
21	8	.5	1.9	.07
22	7	.8	2.2	.7
23	7	.9	1.7	.4
24	5	.6	1.9	.2
25	5	.2	1.08	
26	4		1.3	
27	4	.2	1.2	
28	3	2.3	1.6	
29	3	1.2	1.6	
30	3	2.1	.13	
31	2	2.6		
32	2	1.5		
33	2	3.8		
34	2	3.7		
35	2	1.3		
36	2	2.5		
37	2	.4		
38	2	2.4	.4	.2
39	2	2.4		
40	2	.7		
41	1	3.4		
42	1	3.		
43	1	.4		
44	1	5.		
45	1	4.6		
46	1	.6		
47	1			
48	1	1.8		
49	1			
50	1			
51	1	1.6		
52	1			
53	1			
54	1	3.6		
55	1			
56	1	2.4		

TABLE XI—*Continued*

5 sec. Periods	Number of Reactions		Ave. Time of	
		Movement	Imagery	Imagery & Movement Combined
57	1	1.8		
58	1	2.4		
59	1	4.		
60	1	4.2		
61	1			
62	1	4.		
63	1	1.6		
64	1	3.4		
65	1	4.		
66	1	4.6		
67	1	4.8		
68	1	2.8		
69	1	.2		
70	1	2.8		
71	1	3.4		
72	1	1.2		
73	1	.8		
74	1	2.		
75	1	4.		
76	1	2.6		
77	1	2.		
78	1			
79	1			
80	1	3.2		
81	1	2.8		
82	1	3.2		
83	1	1.		
84	1			
85	1			
86	1			
87	1			
88	1	2.		
89	1	3.2		
90	1	1.2		
91	1	1.		
92	1			
93	1			
94	1			
95	1			
96	1	2.6		
97	1	2.6		
98	1		1.6	

were combined varied in proportion to the time of movement more than to the time of imagery.

Table XII which follows gives the distribution of the time given to imagery, to perceptible movements, and to the two combined throughout the different quarters of the reactions, in terms of the percentage of the total time of the reactions of this sitting.

TABLE XII

Quarters	Movement	Imagery	Move't & Imagery Combined
I	8.4%	11.4%	4.8%
II	7.9	12.9	4.1
III	8.8	12.6	5.5
IV	8.	13.5	4.4
Totals	33.1%	50.4%	18.8%

These results substantiate those of the preceding table as well as those of Sittings I and II in showing that there was a slight tendency for noticeable movements to decrease as the thinking terminated, and those of Sitting II in showing that imagery, on the other hand, tended to increase, although it was more conspicuous in the last quarter of the thinking in this sitting than in that of the previous sitting. The actual time given to noticeable movements was less than a third of the total time of thinking, while imagery was present a little more than a half of the time, as was the case in Sitting II. It is also apparent as before that the most marked increase in imagery appeared after the thinking of the first few seconds. The fact that the time during which movement and imagery were combined varied proportionally to the amount of movement more than to the amount of imagery present is again noticeable.

In this sitting the pause following the presentation of the problem was also frequent, being present in forty-one of the fifty reactions. The average length of this pause was shorter than in either Sittings I or II, being 1.23 seconds long, although the average reaction time for thinking was somewhat longer, 62.6 seconds. This may have been due to the fact that the subjects had become more familiar with the nature of the problems and so adapted themselves more readily to determine their solutions.

During this pause verbal imagery was reported to have been present sixteen times, visual images nine times, and conscious states described in neither of these terms five times. As the results of this sitting do not show the kinds of movement observed, it is impossible to learn what kinds of imagery were accompanied by the definite kinds of movement when this pause was not present.

The average length of the pause preceding the subjects' final signals in this sitting was 5.16 seconds, proportionally as long as the similar pauses in the two previous sittings. During this pause, verbal images were reported to have been present nine times, visual images nine times, verbal and concrete imigery combined nine times, combined concrete imagery twice, and conscious states not described in terms of either verbal or concrete imagery six times. In the remaining fifteen reactions, where no pause was apparent and where movements occurred, these same kinds of imagery were present, but as the kinds of movement observed were not recorded by the experimenter, the exact correspondence between the movement and the imagery could not be discovered.

There were two problems in this sitting also which were solved without consciousness of imagery of any sort. They were reported by the same subject, A.[1]

In nine of the remaining forty-eight reactions, imagery was present throughout the thinking, seven of which reactions were of rapid thinking. An interrupted flow of imagery, therefore, characterized 78 per cent of the reactions. Eight reactions were said to have contained merely verbal imagery, five of which were quick reactions. Four reactions were described as having merely concrete imagery, all of which were examples of rapid thinking. The remaining 36 reactions were presented in both concrete and verbal terms. As for the actually original parts of the thinking, the subjects' retrospections showed that seventeen were present in merely verbal terms, ten in terms of concrete imagery alone, while fourteen included both the concrete and verbal elements. In six actually novel parts of the thinking, however, the subjects were not able to report the presence of either form of imagery: three appeared suddenly "like a flash" and so defied analysis, three were "facts" or "notions" impossible to describe, while three the subjects were doubtful about.

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[1] Problem III. 8. If you should start now for the Battery, how could you possibly reach there in half an hour? Ans.: I had a feeling of being directed toward the subway, the map, and the real place: the harbor, the Statue of Liberty. I was not seeing, just being directed toward them. I thought of the elevated but rejected them almost before they came to mind. I thought: It takes longer than half an hour, I couldn't go. I was conscious of the fact that it was impossible, (a conclusion she had not thought of before). No imagery. T. 20 seconds.

Priblem III. 9. What historic character would you choose to write a play about? Ans.: I first thought of Joan of Arc as she is my favorite character, but I thought Schiller had done it better. Then I thought of my general principle that I would never write anything that was not scientific, so I gave up any idea of writing a play. My mind jumped from one side to the other. I was conscious of the conclusion before I described it. No imagery. T. 10.2 seconds.

A study of the correspondence of movement and imagery as found in the kymographic records shows that when the actual time given to each was measured, imagery was less often accompanied by movement than not, 37.9 per cent. When the verbal images could be differentiated from the concrete images by comparing the kymographic records with the subjects' retrospections, it was found that the former were more often without noticeable accompanying movements than with, 56.7 per cent. When the visual images were similarly singled out, 40.2 per cent of them were found to have been accompanied by perceptible movements. When the memory visual images could be differentiated from the imaginary ones, they were found to have been more often accompanied by movement, 49.1 per cent, than were the imaginary images, 24.2 per cent. This correspondence between movement and imagery in this sitting, it must be remembered, simply refers to movement in general, as no record of the kinds of movement was kept by the experimenter.

The periods in which imagery was absent, 105 in all, were more often described as active than passive, 63.8 per cent being accompanied by a feeling of progress, while many of the others were described as "breaks," "cracks," or "blanks" in the thinking.[1] As in Sitting II, the majority of passive periods were not accompanied by perceptible movements, 68.4 per cent. In 82 per cent of the active states, on the other hand, some movements were noticeable.

The following table, Table XIII, gives variations in imagery and movement in proportion to the length of reaction time. These results, too, show characteristics similarly pointed out in Sitting II. Imagery again failed to characterize both the most rapid and the slowest thinking.

There was practically no correspondence between the presence of imagery and of perceptible movements, although both the imagery and the movement were frequently combined.

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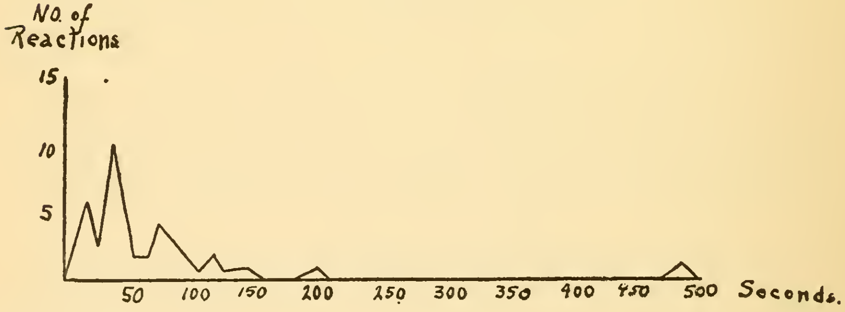
[1] Are these instances in which thought is "baffled"? Fox, C. The Conditions which arouse Mental Imagery in Thought. Rep. Brit. Ass. for Adv. Sci. 1913, LXXXIII. p. 688, and Betts, op. cit. p. 94, state that such conditions are especially favorable for arousing mental images.

TABLE XIII

Reaction Time	No. of Reactions	Av. time of Movement	Av. time of Imagery	Av. time of Imagery and Movements Combined
-10 sec	2	3.1 sec.	1.3 sec.	.9 sec.
10-20	6	11.1	7.1	5.3
20-30	3	19.8	47.8	10.2
30-40	11	14.07	19.9	14.8
40-50	7	15.1	26.8	10.4
50-60	2	9.	29.4	3.2
60-70	2	25.1	25.8	15.5
70-80	4	42.2	35.	27.0
80-90	3	10.4	59.9	6.8
100-110	1	19.4	84.2	16.6
90-100	2	30.8	47.4	1.7
110-120	2	21.5	60.8	15.9
120-130	1	19.4	97.8	19.2
130-140	1	24.4	3.	1.2
140-150	1	23.	138.6	21.4
190-200	1	59.6	3.2	.8
490-500	1	64.8	5.	.4

The following graph, Fig. V, gives the distribution of the reactions of this sitting according to the length of their duration in terms of seconds.

FIG. V.



FIFTY THOUGHT REACTIONS
(Arranged according to time required for thinking)

As in Sittings I and II, it is possible to divide these reactions into three classes: "rapid" (less than 60 seconds), "moderate" (between 60 and 100 seconds), and "slow" (over 100 seconds). Again, as in the previous sittings, the majority of the reactions, 31, were rapid.

TABLE XIV

Kinds of Reaction	Number of of Reactions	Av. time of Reaction	Av. time of Movement	Av. time of Imagery	Av. time of Imagery and Movement Combined
Rapid	31	33.05 sec.	15.4 sec.	17.3 sec.	9.6 sec.
Moderate	11	80.9	28.9	42.4	8.1
Slow	8	176.7	31.7	56.6	11.4

The results given in the above table show, as in Sitting II, the lack of a proportionate amount of imagery in instances of slow thinking. As for the instances of rapid thinking, it is true, as in Sittings I and II, that most of the reactions in which imagery was present throughout, 7 of the 9, were quick reactions. But it is also true, as in Sitting II, that all of the reactions which were described as wholly imageless were in this group. These imageless reactions were rapid even for this group, being 20 and 10.2 seconds in length respectively, but there were many reactions which were shorter and which contained imagery. All of the reactions whose actually novel parts were described as imageless were also instances of rapid thinking. On the other hand, all of the reactions which contained merely concrete imagery were of this group of quick reactions, and five of the eight which contained merely verbal imagery were also of this group. As in the previous sittings, therefore, rapid thinking may be characterized by a preponderance of imagery, especially of a single kind, or of imageless states. Finally, the combination of imagery and movement showed no variability proportional to the length of reaction time, to the amount of imagery, or to the amount of movement.

Individual differences in rapidity of thought are apparent in this sitting, as in the previous ones. A, G, and H were quick in all of their reactions, D, E, and J were not slow, while B was not quick. In comparison with the earlier results, A, H, and J still held their records of both previous sittings, while subjects D and E showed the same rate of thinking which they had in Sitting I.

Finally, from the results of this sitting, it was possible to secure certain correlations. By using the fifty reactions of this sitting, speed of thinking correlated with the amount of time given to imagery, to movement, and to imagery and movement combined as follows:

Speed of thinking with:		
	Imagery	$r = .21$
	Perceptible movements	$r = .19$
	Imagery and movement combined	$r = -.04$

When the quick, slow, and moderate reactions were in turn considered, their speed of thinking correlated with the amount of time given to imagery, to movement, and to both in combination, showing the following correlations:

Speed in rapid thinking with:	(31 reactions)
Imagery	r = .59
Perceptible movements	r = .401
Imagery and movement combined	r = .32
Speed in moderate thinking with:	(11 reactions)
Imagery	r = .32
Perceptible movements	r = —.01
Imagery and movement combined	r = —.002
Speed in slow thinking with:	(8 reactions)
Imagery	r = —.41
Perceptible movements	r = .09
Imagery and movement combined	r = —.46

With the fifty reactions of the sitting, the time of imagery which was recorded, and the time during which movements were perceptible showed a correlation of r = .2009.

Finally, when the results of Sittings II and III were combined, it was possible to get the correlation between imagery and speed of thinking with the following results:

Imagery with:	
Speed of thinking (100 reactions)	r = .17
Speed of rapid thinking (63 reactions)	r = .506
Speed of moderate thinking (20 reactions)	r = .35
Speed of slow thinking (17 reactions)	r = .—46

The information given by these correlations is similar to that already submitted. In general, imagery and speed of thinking were not correlated to any degree, while the relationship between speed of thinking and perceptible movements was even less close. However, the more rapid the thinking, the more apt it was to have been accompanied by imagery. This is true in spite of the fact that two instances of rapid thinking were reactions which did not contain imagery. Although based upon but relatively few instances, the high minus correlation between slow thinking and imagery suggests the possibility that the slower the thinking, the less the imagery, a fact somewhat substantiated by the results of Sitting II. Imagery was not correlated to any extent with perceptible movements in general.

As four of the eleven instances of moderate thinking showed a negative relationship between the amount of imagery and the speed of thinking, while six of the eight instances of rapid thinking showed this characteristic, it seems likely that those reactions between 95 and 105 seconds in length were those which showed no relationship whatsoever between imagery and speed of thinking. This reaction time resembled very closely that similarly obtained in Sitting II.

The correlations secured when the reactions of both sittings were combined were very much the same as those which had been given in each sitting, further corroborating the conclusions already stated.

The results of this sitting, as has already been shown, have offered further evidence to support the conclusions drawn in Sittings I and II. Moreover, they seem to present sufficient evidence upon which to base the following conclusion:

1. Perceptible movements accompany thinking during not more than one-third of its total time. They come and go at irregular intervals, with the exception of the pauses immediately after the presentation of the problem and just prior to the subject's final signal.[1]

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[1] Already noted above, p. 34.

CHAPTER VI.

SITTING IV.

It was the purpose of this sitting to learn, if possible, how close the relationship between imagery and relevant movements could be. The following results of Sitting II, already noted, indicated that a possible connection existed between imagery and movement, such that one might expect that movements had been constantly accompanying the images but were in themselves too minute to be readily detected by an onlooker.

1. Of the 301 relevant movements recorded by the experimenter, 8.8 per cent were eye movements which accompanied visual imagery, while 10.8 per cent were lip movements accompanying verbal images.

2. 46.7 per cent of the periods where imagery was present were accompanied by relevant movements.

3. Of the 86 visual images, 32, or 37.2 per cent, were accompanied by noticeable eye movements, while of 104 verbal images, 49, or 46.1 per cent were found to have had accompanying lip movements.

No description of the "verbal images" which entered into the subjects' thinking has been attempted up to this point, as it was difficult for the experimenter, even with the help of the objective records, and, in many cases, for the subject to determine to what extent the imagery was in reality inner speech. The subjects were allowed to describe their verbal elements in any terms they wished,[1] and as six of them nearly all of the time, and all of them some of the time referred to it as "imagery,"[2] the experimenter has always referred to it as such up to this point, until an opportunity should arrive for differentiating between the two.

Various forms of distraction were introduced in this sitting in order to detect the degree of the connection between imagery and accompanying movements.[1] The visual distraction was a white bob swinging in a large arc over the head of the experimenter. The subject was asked to solve a problem which was likely to arouse visual imagery[2] while he gazed constantly at the swinging bob. The experimenter in the meantime recorded the failures of the subjects to follow this movement, pressing her key when the gaze wandered, and releasing it as soon as it was again fixed on the bob.

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[1] The following expressions were used: "vocal motor," "auditory motor," 'auditory kinaesthetic," "auditory," "visual," and "verbal" imagery.

[2] Three subjects, C, F, and H, questioned as to whether or not some of their verbal images gave them kinaesthetic sensations. Subjects A, B, and C decided that some of their images were sensational, while Subject I admitted that he frequently talked to himself.

The auditory distraction was a bell rung from the moment the problem had been presented until the subject's final signal was given. The problem was selected as one which would be likely to require auditory imagery for its solution, in order to determine whether or not there would be interference between sensations and images of the same kind. During the solving of the problem the experimenter recorded the subject's movements, as in Sittings I and II.

The verbal distraction was the repetition aloud of a b c, a b c, a b c, etc., as fast as possible. The subject was given a problem which was likely to require verbal imagery for its solution. The experimenter recorded the presence of any hesitation or confusion on the part of the subject in pronouncing the letters.

Finally, each subject was given a problem which it was believed would require hand-motor imagery for its solution. The subject was asked to keep the thumb and forefinger of each hand in a simple rhythmical motion which he had previously practiced, so that it could be carried on automatically during the solving of the problem. The experimenter kept a record of any hesitation in this movement.

The kymographic records of this sitting showed the time in fifths of a second and the records of the experimenter, which varied with each problem as described above. The answers of each subject to the required questions were recorded verbatim, as in the previous sittings.

The results of the experiment with the visual distraction showed:

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[1] A similar use of distractions has been made by Münsterberg, H., and Campbell, Psych. Rev. 1894, I. p. 441, Smith, T. L., Am. J. of Psych. VII. 1896, p. 459, Secor, W. B., Am. J. of Psych. 1897, XI. p. 232, Cohn, J., Zsch. f. Pysch. 1897, XV. p. 161, Meumann, E., Ueber Oekonomie and Technik des Lernens, 1903, Segal, J. Arch. f. d. ges. Psych. 1908, XII. p. 124, Fernald, M. R., Psych. Rev. Mon. 1912, XIV. No. 58, and Pintner, R., Psych. Rev. 1913, XX. p. 129.

[2] See Appendix p. 93.

(a) Two subjects were completely distracted. They could not solve the problem.

F acknowledged that he was dependent upon visual fixation in his thinking. He was given another problem which he solved, but his eyes glanced aside from the swinging bob several times, during which he admitted his thought progressed.

A admitted that she could not attend to both the swinging bob and her imagery. She was given another problem and failed again. She then asked for a problem which would not require visual images. She was given one which could be solved by verbal imagery which she succeeded in solving without the aid of visual images. She was still distracted, however, and the experimenter's record showed that her gaze wandered several times. She was apt to use visual images in her thinking.

(b) Five subjects reported that they were distracted but still able to solve the problem. In all of these reactions visual images were said to have been present, and the experimenter's records showed that the eyes frequently failed to follow the bob. All of the subjects reported that they became aware that the motion of the bob interfered with their imagery so that they often wondered whether or not their eyes were following its motion. Some admitted that they had to voluntarily attend first to the one, then to the other, in order to accomplish the task. The eye movements recorded by the experimenter took place at periods in the thinking at which images were reported. Two subjects confessed that they were conscious of the side glances from the bob, but added that they were not done intentionally.

(c) Three subjects, H, I, and J, reported that they were not at all distracted. They said that they felt no disturbance, having images in their usual way. Subjects H and J were found to have used eye movements to the side at times when judging from the subjects' retrospections, visual imagery was reported to have been present. Of these eye movements the subjects seemed to have been wholly unconscious. The experimenter was unable to discover that Subject I looked away from the bob at all.

Fourteen visual imagination images were described in nine of the ten solutions. With nine of these images, the experimenter's records showed that the subjects' eyes had looked away from the swinging bob at points in the thinking which corresponded to the report of images in the subjects' introspections. With visual memory images, also, eight of the ten described were accompanied by such side glances.

The swinging movements of the bob would interfere with habits of visual fixation as well as with ocular movements relevant to the image itself. Two subjects definitely reported that their difficulty was due to an inability to fixate their gaze upon some one spot. This visual fixation did not seem to be related to any one special kind of imagery,[1] for with Subject F the images were those of memory while in the case of Subject C the images were novel and full of movement. On the contrary, this visual fixation characterized the general bodily adaptation of these subjects to the solving of all problems[2] and seemed to be merely a means of avoiding visual distractions.

The reasons for the side glances of the remaining seven subjects may then have been due to interference with slight movements accompanying the images.[3] But the difficulty definitely described by five subjects was that of control of attention. They stated that they were forced to attend alternately to the distraction and to their thinking. If the turning of the attention to the thinking, however, involved ocular movements other than those of following the swinging bob, such movements must have been inseparably connected with the contents of thought or with an unconscious habit of visual adaptation to the thinking.

The three remaining subjects who reported that they were not distracted must have adapted themselves automatically to following the swinging bob and so were able to attend more easily to the contents of their thoughts. But as two were found by the experimenter to have made glances to the side, this automatic motion must have interfered either with an unconscious habit of visual fixation or with incipient ocular movements accompanying visual images.

It cannot be said conclusively, therefore, that visual images were invariably accompanied by ocular movements. The above results seem to indicate that either visual fixation was necessary for better concentration of attention upon mental states, or slight eye movement accompanied the visual imagery which was present. In the case of Subject I, however, the possibility still remains that neither visual fixation nor ocular movements with his visual images were necessarily present.

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[1] Perky, C. W. Op. cit. p. 451, asserts that there is 100% visual fixation for "imagination" images, while Clark, H., op. cit. p. 491, states that there is lack of ocular movements when the usual conditions of perception are least reinstated by the image.

[2] See above, p. 28 ff.

[3] Cf. Clark, H., op. cit. p. 487.

The results of the experiment with the auditory distraction show that (a) four subjects were distracted, but still able to solve the problem. Subject E was emotionally disturbed, as she was wont to be by the sound of any bell. She solved the problem, however, and had, during her thinking, auditory verbal imagery. C and G were unable to call to mind certain names. C, however, succeeded when she tried another set of associations: the name coming in terms of auditory motor imagery.

(b) Two subjects reported the presence of concrete auditory imagery while hearing the sound of the bell.

(c) All subjects described their verbal elements as auditory, showing the presence of auditory imagery.

These results indicate that an auditory sensation did not necessarily inhibit the consciousness of imagery of the same kind. This is not surprising, as visual imagery was constantly being reported in the thinking which was carried on with open eyes.[1]

A study of the results of the experiment with the verbal distraction shows:

(a) Three subjects were completely distracted.

G reported that he "couldn't get anywhere" with the problem. He was given another which he succeeded in solving, as his verbal imagery "slipped in" during the periods when he stopped for breath.[2]

E reported that she felt "very self-conscious." She failed to solve two problems, but succeeded with a third, during which her verbal imagery appeared when she paused to breathe.

C was not able to reach a new conclusion for her first problem. She solved a second problem by letting her verbal images slip in between the repetition of the letters.

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[1] Cf. Fernald, M. R. Op. cit. pp. 119 ff.

[2] Smith, T. H. Op. cit. p. 453 ff., Fernald, M. R., op. cit. p. 119, and Pintner, R., op. cit. p. 140 report similar results in the presence of verbal distractions.

(b) Two subjects, G and H, consciously abandoned their verbal images, solving the problem by means of concrete imagery.

(c) Three subjects were but slightly distracted. A and I confessed that their verbal imagery crept in when they paused during the repetition of the letters. F, on the other hand, so controlled his verbal images that they went simultaneously on "in his head."[1] The experimenter noted that he made a short pause in the repetition of the letters. Here the subject explained that he stopped "to give his points a hang."

(d) Two subjects were not at all distracted.

D used verbal imagery throughout, feeling no conflict between the two. She said she could "go on doing it forever." She paused three times for breath.

J did not report the presence of verbal images. The problem was solved in visual terms. His rate of repetition was noticeably retarded three times, however, although he said he was not distracted, as the repetition of the letters went on mechanically. His conclusion presented itself as a "notion."

These results seem to indicate that with some individuals articulatory movements are necessarily connected with their verbal elements in thinking. Their "verbal imagery" has, therefore, probably been, throughout the solving of their problems, inner speech. In the cases of D and F, however, the possibility still remains that they may have experienced actual verbal images.[2]

The experiment with the hand-motor distraction gave the following results:

(a) One subject was completely distracted. Subject A reported that if she had worked out the problem she "would have had to draw it." She was conscious of distraction continually. When a second problem was given she gained an "abstract knowledge" of it, but the solution did not come until she had stopped moving her fingers. A third problem she solved by talking aloud, finally stopping the movement of her fingers in order to complete the thought. She said that if she were given another kind of problem she could solve it in spite of the distraction.

(b) Three subjects were slightly distracted.

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[1] Pintner, R., op. cit. p. 152 reports a similar change in the presence of verbal distraction.

[2] Reed, H. B. Inner Speech in Thought Processes. J. of Exp. Psych. 1, 1906, p. 372, admits this possibility.

B wanted to stop her finger movements in order to draw. She felt sensations of movement in her arms and hesitated several times in her finger movements. She solved the problem in verbal terms.

D also wanted to use her hand for drawing, but finally resorted to visualizing the movements.

G became confused and stopped moving his fingers. He continued in a moment, however, and solved the problem by concrete images.

(c) Six subjects reported that they experienced no distraction. C, F and I made use of hand-motor images, but reported that they felt no conflict between the movements made by their fingers and their motor images. All of their records, however, showed the presence of moments of hesitation in the movements of their fingers.

E, H, and J reported no hand-motor imagery in their solutions. In the case of E, however, there were three short pauses in her hand movements. H and J, on the contrary, showed no confusion or hesitation in their hand movements.

These results seem to indicate that with some individuals, motor imagery and incipient movements are inseparably connected. The possibility still remains in the cases of Subjects C, F, and I, however, that they may have experienced actual motor imagery apart from movement.

Summarizing the results of this sitting, the following conclusions seem justifiable:

I. Auditory and visual sensations do not inhibit the consciousness of imagery of the same kind.

II. With some individuals, visual images are inseparably connected with either visual fixation for better concentration of attention, or with slight relevant eye movements.

III. With some individuals, verbal imagery is inseparably connected with articulatory movements, showing that their "imagery" is in reality "inner speech."

IV. Hand motor imagery with some individuals is likewise inseparably connected with incipient hand movements.

V. There is no conclusive evidence that imagery is thus inseparably connected with movement for all individuals.

CHAPTER VII.

SITTING V.

On account of the lack of conclusive evidence that verbal imagery and articulatory movements are inseparably connected, this sitting was planned in which minute tongue and laryngeal movements could be measured by means of delicate apparatus.

Four subjects were examined in this way: A, who alone reported that she had solved problems without the presence of any kind of imagery, and who was found to have resorted to inner speech in Sitting IV; B, who had described her verbal elements throughout as images, but who showed confusion in the presence of verbal distraction; C, who was not always certain about the character of her verbal elements, but who was unable to solve her problem in the presence of a verbal distraction; and D, who carried on her verbal images with ease in the presence of the verbal distraction.

The work of this sitting was carried on in the Neurological Laboratory of the School of Physicians and Surgeons. The subjects were seated as comfortably as possible in a chair. They were given problems to be solved in the usual way, except that, during the thinking, records were made of their respiration, thoracic and abdominal; the changes in volume of the arm; their laryngeal movements, horizontal and vertical; and their tongue movements. The time record in fifths of a second was also kept, as well as a record from the experimenter's key which indicated the time of the presentation of the problem and the duration of the thinking. The kymographic records, therefore, showed eight separate tracings taken simultaneously.[1]

Sumner pneumographs were used to measure the changes in respiration. Lehmann's water plethysmograph measured the volume of the arm. To detect the laryngeal movements, two tambours were used, Fig. VI. The upper one was cup-shaped with a rubber membrane stretched over the top. This was fitted over the front of the throat and responded to the horizontal movements of the larynx. This tambour was fastened to the throat by means of a headpiece in such a way that

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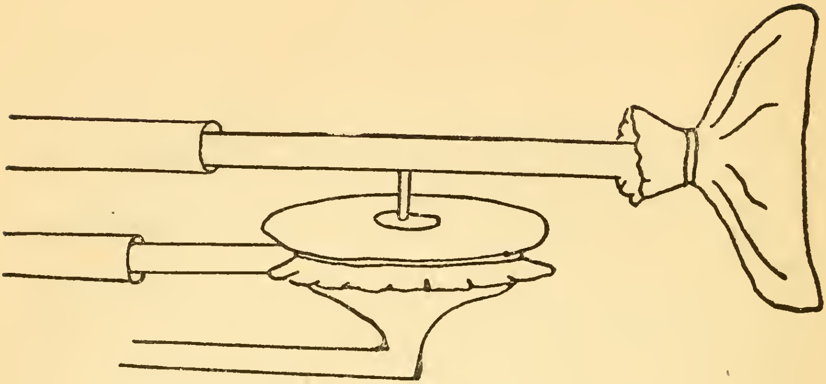
[1] See Figs. IX, X, X, XIX, Appendix p. 97 ff.

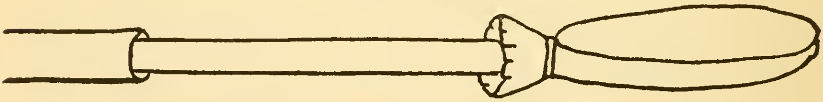
Fig. VI



Instrument for measuring laryngeal movements

the entire tambour moved up and down with the vertical movements of the larnyx. In order to record these vertical movements, the stem of the cup-shaped tambour was attached at right angles to a second tambour which responded to these changes in position of the first. The tongue movements were recorded by means of a small flat frame, the size of the mouth, which was covered with a rubber membrane, Fig. VII., and placed in the mouth above the tongue.

Fig. VII



Instrument for measuring tongue movements

A continuous roll kymograph was used, run by electricity. The recording tambours were placed vertically on a frame above the kymographic paper. Their needles fell with the force of gravity upon the drum and recorded the movements of the tambours on the revolving sheet.

Under such conditions the subject was forced to sit perfectly still during the solving of the problems, thus eliminating all gross bodily movements. After the problems were solved the subjects' answers to the required questions were recorded verbatim, as in the previous sittings.

Subject A in her three problems reported the presence of verbal elements. She said they came "somehow" but she didn't know just how. The kymographic record showed the occasional presence of inner speech in each reaction, as tongue movements were noticeable.[1] Laryngeal movements were occasionally recorded when the tongue was especially active in the first and last reactions. In the second reaction, however, the inner speech seemed to have been carried on by the tongue alone.

The volume of the arm, for subject A, showed a high pressure which was steadily maintained, not only during the period just before the problem was given, but during the presentation of the problem and the thinking, showing a slight gradual tendency to increase as the thinking progressed in the first and last reactions.[2]

The rapidity of the pulse, as recorded in the plethysmographic curve, showed no noticeable changes either before or after the presentation of the problem, or with the rise in the volume curve.[3] The amplitude of the pulse curve, however. showed a slight diminution with increase in volume.[4]

This subject's respiration records showed more marked differences between the periods of rest, of perception of the problem, of thinking, and of actual speech, than did any other records. Before the problem was presented her respiration was slow, deep, and regular. With the presentation of the problem it immediately became more rapid and superficial, although it still remained regular. This continued for a short period following the presentation of the problem[5] and then the breathing became deeper so that it resembled the normal rate when the problem was solved.[1] When the subject started to speak at the end of the reaction, marked changes in the breathing curve were of course made.

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[1] Courten, H. C. Involuntary Movements of the Tongue. Yale Psych. Studies 1902, X. p. 94 reports the presence of tongue movements of which subject was not aware.

[2] Either constriction or dilation in the volume curve may accompany mental work according to Binet, A. and Courtier, J. Les Causes d'Erreur dans les Expériences de plethysmograph. L'Ann. Psych. 1895, II. P. 162 and Angell, J. R. and Thompson, H. B., Organic Processes and Consciousness, Psych. Rev. 1899, VI. p. 39.

[3] Regularity in the heart beat under sustained attention has been noted by Binet, A., and Courtier, J., op. cit. p. 158, and by Angell, J. R., and Thompson, H. B., op. cit. p. 48.

[4] This relationship between the volume curve and the amplitudes of the pulse record is affirmed by Binet, A., and Courtier, J., op. cit. p. 129, and by Lehmann, A., Die körperlicher Aeusserungen psychischer Zustände, but denied by MacDougall, R., The Physical Characteristics of Attention, Psych. Rev. 1898, III. p. 176.

[5] The rapidity and superficiality of the breathing in mental work has been reported by Binet, A., and Courtier, J., op. cit. p. 158, by Gamble, E. A. M., Attention and Thoracic Breathing, Am. J. Psych. 1905, XVI. p. 290, and by Stevens, H. C., A Plethysmographic Study of Attention. Am. J. of Psych. 1905, XVI. p. 468.

These results can be contrasted with another reaction of this subject when she did not understand the question, tried to make something out of it, failed and finally gave up. In this reaction the tongue movements became less and less noticeable, the larynx showed no response and there was a marked fall in the volume curve, with a slight diminution in the height of the pulse curve.

The results given in Subject B's two reactions resemble greatly these of Subject A. Verbal elements were reported present in both reactions, the subject describing them as more auditory than motor. Her tongue movements were more minute than those of Subject A, but inner speech was at times noticeable in both reactions, the tongue movements in the solving of one problem being intense enough to have been accompanied occasionally by laryngeal movements.

In one reaction, when the subject thought of knitting, she reported the presence of a motor image of the attitude of knitting. At this point in the plethysmographic curve, a slight hand movement was perceptible, simultaneously with inner speech involving both tongue and larnyx.

The volume curve in the records of this subject showed a slight gradual increase accompanied by a slight increase in rate of heart beat.[2] There was no perceptible decrease in the height of the pulse record as in the case of Subject A.

Subject B's respiration record was similar to those of Subject A.

The results of Subject C's five reactions also greatly resembled those of Subject A. Verbal elements were reported present in all reactions, and described as "more sensory than before" in the solving of the last two problems. This difference was noticeable in the kymographic records. As in the case of Subject B, Subject C's tongue movements were minute. Laryngeal movements were hardly noticeable except in the last two reactions. Inner speech was noticeable in the tongue records of the last two reactions, but it was difficult to detect in the remaining three, although one of these reactions was described as being "just about all in auditory motor verbal images," which, however, were not distinct to the subject.

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[1] Regularity of respiration accompanying periods of special concentration of attention has been reported by MacDougall, R., op. cit. p. 176, and by Angell, J. R., and Thompson, H. B., op. cit. p. 48.

[2] This relationship betwee vaso-dilation and rate of pulse has been noted by Bonser, F. G. A Study of the Relations between Mental Activity and the Circulation of the Blood. Psych. Rev. 1903. V. p. 125.

The volume curves of this subject showed several types of variability. The volume was sustained evenly in the solving of one reaction. In one reaction, it increased gradually as in the case of Subjects A and B. In another reaction, it showed a constriction following the presentation of the problem,[1] rising into a dilation by the time the solution was reached. The remaining reaction showed a constriction following the presentation of the problem, then a dilation, and finally a constriction at the time when the problem was solved.[2] No noticeable differences in the rate of heart beat or in the height of the pulse curve were found to vary with these changes in volume.

The respiration of Subject C differed slightly from that of Subjects A and B in that she tended to hold her breath during the presentation of the problem and immediately following. Then her breathing became more rapid and superficial as was the case with both Subjects A and B.

Subject D solved two problems during both of which "vocal motor imagery" was reported present. Both records showed noticeable inner speech with occasional laryngeal activity. The amount of inner speech, however, did not account for the verbal imagery which she described. It appeared at the beginning of her thinking and disappeared very soon after, in spite of the fact that she reported the presence of verbal imagery throughout. This subject was the one who reported that she experienced no conflict between her verbal imagery and the verbal distractions of Sitting IV.

The plethysmographic curve in one reaction showed a slight constriction shortly after the presentation of the problem. This was accompanied by noticeable hand movements and was followed by a very gradual increase in volume. The height of the pulse curve was slightly diminished as the volume increased. Toward the end of the reaction a feeling of self-consciousness was reported by the subject. The volume curve showed a slight constriction, an effect opposite to that found when Subject A was experiencing the same emotion.[1] The other reaction showed no volume changes, no change in height of pulse curve or rate of heart beat, and but one instance of hand movement during the first part of the thinking when she reported she was slightly distracted by the feeling of her pulse.

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[1] Such a fall in the volume curve has been reported by Binet, A., and Courtier, J., op. cit. p. 162, by Angell, J. R., and Thompson, H. B., op. cit. p. 34, 39, by Shepard, J. F., Organic Changes and Feeling, Am. J. of Psych. 1906, XVII. p. 580, and by Stevens, H. C., op. cit. p. 468.

[2] Cf. Angell, J. R., and Thompson, H. B., op. cit. p. 50.

The respiration of Subject D was similar to that of Subject C in that she tended to hold her breath during the presentation of the problem, but it differed from that of any of the other subjects as the breathing remained superficial up to the last.

A distribution of the different kinds of movement recorded in this sitting is given in the following table, Table XV, throughout five-second periods.

From these results it is apparent that tongue movements were not as frequent in the later parts of instances of prolonged thinking. Laryngeal movements accompanied only part of the tongue movements. Both the rate of breathing and of heart beat were noticeably regular, despite the length of reaction time.[2] However, the rate of heart beat showed a slight tendency to alternately decrease and increase throughout the thinking. The rate of breathing, on the other hand, showed a slight tendency to increase and then to decrease until the problems were solved.

As the total time given to thinking in this sitting was 513.3 seconds, eliminating the one reaction in which the tongue tambour failed to record, the amount of time during which tongue movements were present included 34.7 per cent of the total time of thinking. Vertical movements of the larynx accompanied 22.4 per cent of the tongue movements of inner speech. The horizontal movements of the larynx were less frequently corded, accompanying only 12.4 per cent of the tongue movements.

The table, Table XVI, gives the amount of each kind of movement found in each quarter of the thinking in terms of the percentage of the total time for each quarter.

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[1] Emotions show vaso-constrictions according to Angell, J. R., and Thompson, H. B., op. cit. p. 58.

[2] The regularity of the bodily activity accompanying heightened attention has been noted by Binet, A. and Courtier. J. op. cit. pp. 158 ff. and by Angell, J. R. and Thompson, H. B. op. Cit. p. 67.

TABLE XV.

5 sec. Periods	No. Problems	Av. time Tongue M'v'ts.	Av. time Vert. Lar. M'v'ts.	Av. time Hor. Lar. M'v'ts.	Av. No. Heart Beats	Av. No. Respirations
1	12	2.5 sec.	.30 sec.	.46 sec.	6.4	1.4
2	12	2.5	.49	.45	6.4	1.4
3	11	2.1	.89	.24	6.4	1.4
4	10	1.6	.53	.22	6.7	1.4
5	8	1.02	.37	.12	6.6	1.6
6	8	.8	.08		5.3	1.3
7	6	.8	.20	.04	5.7	1.1
8	5	1.8	.75	.50	5.7	1.4
9	4	2.3	.25	.05	7.1	1.8
10	4	1.	.25		7.3	1.6
11	4	2.2			7.2	1.6
12	4	.2			5.6	1.1
13	3	1.	.06	.06	7.5	1.
14	3	1.	.33		5.5	1.
15	3	.6			5.8	.9
16	2	1.	1.		8.2	1.3
17	1				6.5	1.
18	1	1.		.50	6.5	1.
19	1				6.5	1.
20	1	.5		.50	6.5	1.
21	1				6.	1.

These results show that inner speech tended to occur more frequently at the beginning of the thinking, being seldom apparent during the last quarter of the reaction. The verbal elements which appeared in the last quarter, however, were more apt to involve both tongue and laryngeal movements than were those in the earlier part of the thinking. The pulse rate showed a slight alternating increase and decrease,[1] reaching its height in rate at the end.[2] This seemed to be independent of the changes in rate of respiration as recorded in the last column of the table.[3] The breathing tended to increase

TABLE XVI.

Quarters	Tongue M'v'ts.	M'v'ts. of Vert. Lar.	M'v'ts. of Hor. Lar.	No. of Heart Beats	No. of Respirations
I.	51.5%	6.4%	7.8%	178.5	33.9
II.	28.1	9.8	2.8	180.5	39.4
III.	35.1	5.1	2.6	176.2	40.4
IV.	13.7	7.4	2.6	181.2	39.
Av.	32.1	7.1	3.9	179.1	38.1

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[1] Similar alternations of pulse rate have been reported by MacDougall, R. op. cit. p. 163, and by Angell, J. R. and Thompson, H. B. op. cit p. 68.

[2] Cf. Binet, A. and Courtier, J. op. cit. p. 163.

[3] Cf. Binet, A. and Courtier, J. op. cit. p. 139 and 158, and Angell, J. R. and Thompson, H. B. op. cit. p. 68.

after the presentation of the problem, and then to decrease slightly.

Of the twelve reactions in this sitting, seven showed the presence of the initial pause during which no inner speech could be detected in lip or laryngeal movements. The average length of this pause was 2.1 seconds. Five reactions only showed a final pause, just preceding the subject's final signal. The average length of this pause was longer, 5.3 seconds. This decrease in the number of initial and final pauses reported in Sittings I-III may indicate that minute speech movements were being made by the subjects during these pauses which could not be observed by the experimenter. But it is noteworthy that these pauses did exist even when the apparatus was delicate enough to detect the slightest articulatory movements.

An examination of the subjects' retrospections of the reactions which showed these final pauses, discloses the fact that in each case verbal elements were present in consciousness throughout the novel part of the thinking, although these verbal elements were not noticeable in the record of tongue and laryngeal movements. Subject A described her verbal images as faint and said that she herself could not tell whether or not they were kinaesthetic. Subject C reported that she could perceive motor accompaniments with her verbal elements during the early part of her thinking, but she did not refer to the nature of the verbal elements which followed. In the other three instances these verbal elements were described as "anditory-motor," "vocal-motor," and "auditory-kinaesthetic" verbal "images," which they undoubtedly were, as they did not involve muscular reactions which could be detected by the most delicate apparatus.

Furthermore, a closer comparison of the subjects' retrospections with the kymographic records shows a suprising correspondence between articulatory movements and verbal elements reported to have been present in consciousness. On the other hand, there is the equally surprising fact that frequently the verbal elements which were described by the subject had no counterpart in movement of tongue or larynx as shown by the kymographic records. This lack of evidence of motor accompaniments for verbal elements in consciousness stands in support of many of the results given throughout this investigation: that there are verbal images which are not instances of inner speech.

As in this sitting the time during which inner speech was present was recorded, it was possible to correlate speed of thinking with inner speech. As a result, $r = .606$ which seems to grant to inner speech an important place in thought.

Finally, from the results of this sitting the following conclusions seem justifiable:

I. Many of the verbal elements in thinking are words actually articulated by the individual. Some of these verbal elements involve movements of both the larynx and the tongue. Others consist in merely minute tongue movements.

II. When an individual is uncertain as to the nature of his verbal elements, or even believes them to be images, the presence of accompanying motor reactions may still be detected by the use of delicate instruments.

III. Some verbal elements in thinking, however, are not found to involve articulatory movements, and so are apparently actual images.

IV. The greater part of thinking is carried on in terms other than inner speech.

V. Inner speech, however, plays an important part in thought as the correlation between the amount of the former, as compared with the amount of the latter, is fairly high ($r = .606$).

VI. The vaso-motor and respiratory accompaniments of thinking show a marked regularity, with slight changes brought about gradually. Respiration is more readily affected by thinking than is the volume of the arm or the pulse rate. The respiratory and the vaso-motor functions, moreover, seemed to be independent of each other.

CHAPTER VIII.

INDIVIDUAL DIFFERENCES.

Before summarizing the results of this investigation, a consideration of the individual subjects and of their characteristic modes of silent thinking should be given.

Subject A.

A rapid thinker: all fifteen reactions were instances of rapid thinking. A.D. from the average reaction time for thinking, —22.1 seconds.

An "active" thinker: A.D. from the average in perceptible movements, +25.3 per cent. Minute movements were detected with verbal, visual, and hand-motor images.

Not very dependent upon imagery: A.D. from the average, —20.6 per cent.

Actual type of imagery, visual.

Predominating kind of imagery in novel portions, verbal (inner speech?).

Concrete imagery brought to her the meaning of words, symbolized whole situations, and particularized general and abstract thinking. Several times it appeared and she followed it to novel ideas.

In "real thinking" she said words were present. But five problems were solved without the consciousness of either concrete images or verbal elements, and six of eighteen reactions showed that the novel part of the thinking was carried on in this imageless state. Such conclusions came as "facts" or she was aware of them before they were hardly conscious. Moreover, she reported she once gave up trying to think "rationally" and gave way to the "associative processes" which produced a conclusion which could not be described as verbal or concrete.

After having heard the problem she did not repeat it verbally, unless her attention wandered or she found difficulty in solving it. Usually she retained an "Einstellung" toward the problem which she could not describe in terms of concrete or verbal elements.

Subject B.

A moderate thinker in regard to speed: Seven of fifteen reactions were instances of moderate thinking. A.D. from average, +17.1 seconds.

Apparently a quiet thinker: A.D. from average in perceptible movements —20.4 per cent. But minute movements were detected with her visual, verbal, and hand-motor images.

Very dependent upon imagery in her thinking: A.D. from average +35.6 per cent.

Actual type of imagery: mixed, visual and verbal.

Predominating kind of imagery in novel portions, verbal (inner speech?).

Concrete imagery alone was present in one reaction and accompanied verbal elements in eighteen. They apparently came as alternatives which she either accepted or rejected, frequently in verbal terms, depending upon whether or not they were "significant to the train of thought." Once, when no alternative came, she "made a strong attempt to get some kind of imagery." Verbal elements frequently accompanied the concrete images which were "more or less objective. The verbal is personal; no difficulty in having them simultaneously. One is the background of the other."

But these verbal elements were not the act of thinking. The words of the problem were often repeated, accompanied by "a feeling of blankness" in the thought. "I had a long feeling of dullness, with verbal images, but didn't feel I was getting anywhere." When progress was made, on the other hand, the verbal elements were "not whole phrases. Only the high spots are touched. They are fragmentary. I could not give a complete description of them. One phrase lingers until I strike the next."

"Thinking itself goes on in an undercurrent, not exactly verbal. I am conscious of a phrase which I then express. Then I go on to the next." "A running comment keeps going on. It is hard to detect. There may be pauses but it is hard to detect them." "Thinking seems also to imply inflections and modulations of the voice, auditory and motor imagery, which is not verbal." A sudden solution she described as "a sort of quick catching at an idea" which she found to be in verbal form. Her inner speech, as shown in her records of Sitting V, was only occasionally present, showing spaces in which this "running comment" may have been present, but not perceptible as speech.

When the problem was presented, she usually repeated it in verbal terms when certain words were emphasized. "The problem may go on repeating itself with different emphasis on different parts." Sometimes this became mechanical: "After several moments of mechanical repetition of the problem, I made myself get an impetus to go on." But usually this repetition is resorted to merely until the "problem becomes synthesized. Then I have a sudden feeling that I have the meaning compactly. After the meaning is clear, "there is a settling down to the problem." Then comes "waiting for the set to bring up something."

Subject C.

Average in speed: Eight of fifteen reactions were instances of rapid thinking. A.D. from the average, —.5 seconds.

Apparently a quiet thinker, A.D. from average in perceptible movements, —27.4 per cent, but minute movements were detected with her visual and hand-motor images and with part only of her verbal elements.

Not very dependent upon imagery, A.D. from average, —29.3 per cent.

Actual type of imagery: mixed, visual and verbal.

Predominating kind of imagery in novel portions, verbal.

Concrete imagery appeared with the verbal elements in all of her reactions, but six of the twenty-four actual solutions were presented in terms of concrete imagery independent of the verbal. Imagery seemed to present alternatives, as in the case of Subject B. When she was "casting about" for alternatives there was no imagery, merely feelings of strain sensations. Without imagery she felt "receptive" having no feeling of progress. But when the images appeared, concrete or verbal, she "commented" on them, accepting or rejecting them in verbal terms.

The characteristics of this commentary "were hard to detect": "When I talk to myself I haven't a good idea when images start or stop. These images are so familiar they don't catch my attention." As so little inner speech was perceptible in her records of Sitting V, as compared with her retrospections, her thinking may have been carried on in terms of verbal images, with the exception of the blank periods which she described. However, very little imagery was reported by her at any time.

When the problem was presented, she seldom repeated it in verbal terms, as it usually called to her mind visual images. "When I hear a problem, one or more words are emphasized so that I can find associations for them."

Subject D.

A moderate thinker: Seven of fifteen reactions were rapid, and seven were moderate. A.D. from the average, +11.4 seconds.

An active thinker: A.D. from average in perceptible movements, +14.7 per cent; also minute movements were detected in her visual and hand-motor images and also in her verbal images, although she said these could be carried on independently of vocal movements, even during verbal distraction.

Very dependent upon imagery, A.D. from average +20.3 per cent.

Actual type of imagery: mixed, visual and verbal.

Predominating type in the novel part of her thinking, verbal with visual.

Concrete imagery seemed to have at times the important place in her thinking: "Visual imagery was present all the time, the verbal now and then" or "verbal images were subordinated to the visual. They lacked detail." On the other hand, many times the verbal images were the more important. "The visual images were not important." "Visual images were very fleeting. They had very little to do with the process." "I think the verbal preceded the visual. The visual lingers longer and starts trains of ideas." When they appeared simultaneously, "I would pay attention to one, then to the other" or "sometimes one may be in the foreground, sometimes the other."

She, too, talked to herself a great deal, "While I was seeing this I was saying words here and there to myself." "I said to myself what I would do." Moreover, the following mental states were described at times as verbal: "I wondered," "I had difficulty in deciding" and "I thought." She frequently reported feelings of blankness, especially after she had thought of a possibility and rejected it. And once, with a "gap" in her flow of imagery, she reported: "I don't feel that progress has stopped."

She seldom repeated a problem in verbal terms, as it usually brought immediately to her mind visual images. But with certain problems, she repeated the words "several times," frequently repeating only part of them.

Subject E.

Average in speed: Seven reactions were rapid and six moderate. A.D. from average, +.2 seconds.

An active thinker: A.D. from average in perceptible movements, +27.3 per cent.

Minute movements were found to have accompanied her visual, verbal, and hand-motor images.

Very dependent upon imagery, A.D. from average, +20.5 per cent.

Actual type of imagery: mixed, visual and verbal.

Predominating type in the novel part of his thinking: visual with verbal.

Concrete images at times held a prominent place in the thinking; they clarified meaning, and offered specific evidence when needed. "I thought of it very quickly. Then tested it out. I depended upon visual images for the test." "The visual image was the proof. The idea came first and I tried it out." Usually, however, the verbal elements dominated. "I had verbal imagery with a background of visual pictures." "My imagery was mostly verbal, very few visual images."

Her verbal images often represented remarks to herself: "That won't do." "No, you can't do it, you must reason it out." "I asked myself, are they the best ones?" But they did not represent all of the thinking: "I am never sure of words, but I think quite often they are scattered throughout." They were rather used to make thought explicit: "The verbal elements were to emphasize it. I clinched the idea with words." Again they were used in "pinning" herself down: "I use words when I make an effort to attend." "I use words when I am disturbed."

Thinking itself, however, seemed to be in other terms: "The idea came. I don't know the terms of the idea. I don't think it was verbal." Again, "People and names popped into my head. I held them to test. Definite, but I don't know in what terms." "I knew Farrar before I had her name."

"I thought of cream and cereal. I thought of lots of staple products" without consciousness of imagery. Moreover, imagery was not present in the "transitive periods."

Usually the problem called up visual images to mind so that she did not repeat the words. But a few times, "I heard myself say some of the words of the problem, but I felt no movement in my vocal cords," or "I kept hearing words." These seemed to be the means of keeping the problem in mind. In one instance, however, she nodded her head to emphasize the words and fix her attention. If the meaning wasn't clear she became distracted, so that such measures were necessary. And if the solution did not "come" she had vague feelings of "discontent" and "hopelessness."

Subject F.

Average in speed: Seven reactions were instances of rapid thinking while six were of moderate speed. A.D. from average, —2.9 seconds.

A very quiet thinker: A.D. from average in perceptible movements —27.8 per cent.

However, minute movements were detected with his visual and hand-motor images. The verbal distraction caused him annoyance in Sitting IV; but he claimed to have been able to carry on verbal images independently, although he paused in the verbal distraction perceptibly once.

Very dependent upon imagery: A.D. from average, +37.5 per cent.

Actual type of imagery: mixed, visual and verbal.

Predominating type in the novel part of her thinking, verbal.

Concrete imagery seldom played a nimportant part in his thinking. A few times the situation was all "visualized," but verbal elements were also present. Once the solution, a visual imagination image, preceded the verbal elements. Usually, however, his concrete images only "helped a little." "Visual image doesn't add. It gives no confidence. Not clear. The images are symbolic. Ideas are distinct and come first."

His verbal elements were usually remarks to himself. "I began to talk to myself." "I think I was talking to myself." "I found myself saying to myself," etc.

His thinking, however, seemed to be something else: "Verbal imagery checked me up, but didn't solve it. It keeps you on the track." One conclusion which he found hard to describe was "fitted into old principles. Seemed to fit. Gave feeling that it fitted." Ideas also were "not imagery necessarily." However, his reactions showed that the verbal elements were present throughout most of his thinking.

He often repeated the problem once to himself: "I had to repeat it. I had to sort of force myself to branch off and get started on it." "I started to repeat the question as soon as I heard it. It helped fix it in my mind. It helps solve the question. It helps me get started. Certain things come up." And again, "Images came up in answer to a felt need."

Subject G.

A rapid thinker: Thirteen of fifteen reactions were rapid: A.D. from average, —22.5 seconds.

Average in his amount of perceptible movement: A.D. from average —8 per cent.

Minute movements were found to accompany his visual, hand-motor, and verbal elements.

Not quite as dependent upon imagery as the average, A.D. —11.1 per cent.

Actual type of imagery, visual.

Type predominant in the novel part of his thinking, verbal, with an equally large number of states impossible to describe in concrete or verbal terms.

Usually his visual images were "vague" and "fleeting." "A tiny scrap of imagery seems to stand for a lot of meaning." An image of a submarine was "schematic"; of an automobile, "generalized or symbolic." Once, however, he apparently had a clear image. "I had a picture of an angle outside there," pointing. Later it had lines marked off in it, but then he "was not sure how they appeared."

His verbal images were also hard to describe. From the first, he said he didn't know what a motor image was, so he described his verbal images as auditory. Again, he reported they might be motor and once he admitted: "If I did anything, I said it to myself." In the experiment with the verbal distraction, he gave up one problem, saying "I felt I could solve the problem, if I could talk." Moreover, during the solution of the problems he frequently reported that he had the desire to speak out loud. But these verbal elements were not distinct. When he described a novel conclusion as verbal he was always in doubt about it. "I wasn't conscious of saying this in detail. It was vague." "Verbal, if anything." "I suppose it was verbal."

There were a great many occasions when he could not describe his thinking. Monroe's book came to him as a "thought." "I don't know how I thought of water being staked out." "I had a feeling of relation." Again, "it was all mixed up like a jumble. I couldn't seem to make it clear. It became clear finally." Usually the novel conclusion "all came at once," or "it came quickly with no introduction." Once, however, "the solution came in steps. Sometimes I felt as if I wasn't thinking." The larger part of his thinking was in this indescribable form.

When the problem was presented, it frequently brought up visual images which started his thinking. Usually, however, he had auditory verbal images of one or more words. They "stuck in my mind," "they seemed to stay in mind. They seemed to reverberate and help me stick to the problem." The problem also aroused "sets" in his mind. "I had two sets; one of seeing the city, the other, in an hour"; "a half a dozen sets came before the problem was stated."

Subject H.

A rapid thinker: All reactions were instances of rapid thinking. A.D. from average, —27.4 seconds.

An active thinker: A. D. from average in perceptible movements, +23 per cent.

Minute movements were found to accompany his verbal elements, but not his visual images.

Average in the amount of imagery reported: A.D. from average, +9.3 per cent.

Actual type of imagery: mixed, visual and verbal.

Kind of imagery predominating in novel part of thinking; visual.

Concrete imagery played an important part in his thinking. It was present in every reaction. Alone it solved two problems and represented seven novel conclusions. It was frequently brought to mind by the presentation of the problem, and in one instance the problem was "rethought" in purely visual terms. These images were usually "fleeting."

Verbal imagery was also frequent, once with visual images

"Flickering on top like snapshots." He often questioned himself: "which are the two best" etc.?

When the problem was presented, he frequently reported "auditory verbal images as usual." He recalled the words as they sounded, only occasionally repeating them himself in motor form. "In awareness of problem, imagery was used in details. Sometimes clear and distinct. But in grasp of problem, I was not aware of imagery." When the whole grasp of the problem was not present, the problem was repeated: "When the problem was stated, I had a sort of accumulative idea of the whole. I sort of held it up to the end." "I had a general composite idea of what the problem meant. I won't deny imagery, but it was not definite. Imagery followed immediately. Then I know what I am going to do and what the problem is: a kind of a feeling which carries force."

A good deal of his thinking, however, he could not describe in verbal or concrete terms. "The solution comes in a flash. I don't know what its constituents are: a bare fact, not having specific imagery. It won't persist, but it is more clear than anything else." "Solution comes like a flash. Recognized as such. I might later test it out. Usually I think there is no need of thinking any more about it, and so I turn to the next thing." "Imagery was nearly always present except when I was suddenly realizing the solution or grasping the problem. A sudden realization of the thing I am seeking. It comes as a whole." "I sort of realized that the situation was a composite affair. I didn't think out but a few consequences. I felt I could figure out a good many if I took time." On the other hand, he once experienced a "moment of strain following the problem. Felt expectant until the images followed. I don't know what is present in those periods. I open up the gates to see if something won't come in. If nothing happens, distraction follows and mind wanders." "There is no progress in periods of strain, but they afford opportunities to progress. They are necessary to progress. These periods of strain are periods of the hardest work of all."

Subject I.

A slow thinker: Eight of fifteen reactions were slow. A.D. from average, +48.6 seconds.

Average in amount of perceptible movements: A.D. —3.5 per cent.

Minute movements were found to have accompanied his verbal and hand-motor imagery but none in connection with his visual images.

Dependent very little upon imagery, A.D. from average —47 per cent.

Actual type of imagery: mixed, visual and verbal.

Kind of imagery predominating in the novel part of thinking, visual with verbal.

Usually he described his visual images as visual "awarenesses." "Visual awareness is not imagery. A difference of degree, they are not like actual things. I have not had many visual images. Sometimes these seem real, but usually they are indistinct. They may be of three dimensions. I can think of vague visual awarenesses and of vivid visual awarenesses, but they seem different from images." Once he reported, "when you were reading the problem, I came as near a visual image as I can get." These visual "awarenesses" were "very weak," "not very clear," "fleeting." They played an important part, however, for they "presented suggestions" and "images were present when I was succeeding."

His verbal elements he recognized oftentimes as inner speech: "auditory-motor verbal images which may have been sensory"; "there was actual speaking"; "at times I do talk to myself as I go along. Sometimes I have words as if spoken out to you." These elements were apparently used especially to give definiteness and clarity to his thinking. When the bell was sounding in Sitting IV, he several times spoke out loud. Again, "the problem seemed very abstract and ideal. I used verbal imagery more for that reason." "Inner speech repeated the catch words, "aesthetic," "ideal," etc.

"Thought," he said, "if not inner speech, is kinaesthetic, more actually verbal." The movements, then, seemed to him to constitute the thinking, for kinaesthesis played a frequent part in his thinking. "Acceptance is probably kinaesthetic." "Identifying myself with the person was kinaesthetic." With his idea of generosity he had a "kinaesthetic image," and the feeling that accompanied the " rich apartment" was *high* but of the "poor relations" *flat*. There were blank feelings during his thinking: "Blank periods make you feel you aren't gaining;" but finally alternatives or suggestions "come up" and the thinking progresses. His consciousness of the term "tablets" he described once as "like an imageless thought." Aside from this instance which he could not otherwise describe, he reported the presence of three solutions which he could not account for. They came so fast he could not discover what they were, but he had the feeling that they "fitted in." They seemed to be only "general ideas."

The problem usually called to mind visual images, so that he did not often repeat the question. He received from the start "a sort of set."

Subject J

A rapid thinker: Twelve of fifteen reactions were instances of rapid thinking. A.D. from average, —11.8 seconds.

Average in his amount of perceptible movements: A.D. —2.5 per cent. Minute eye movements were found to have accompanied his visual images.

Not very dependent upon imagery in his thinking. A.D. from average, —16 per cent.

Actual type of imagery: visual.

The majority of his novel conclusions he could describe neither as concrete nor verbal.

Visual imagery played a very important part in his thinking. In sixteen of the nineteen reactions it was the only imagery reported. It was the only kind of novel solution which he could describe. It was usually "vague," "scrappy," "schematic," "faded away," "not distinct or thick." Sometimes it was "not important," and "insignificant," but usually it symbolized a situation: a "map with lines in the direction of England," a "map" with "dots on the map of the submarine section," or a "sweeping schematic view of South America." These schematic images he termed "notions," although he did at times differentiate this term from the image: "not clear, no image, just a notion."

Distinct verbal elements played very little part in his thinking, as they were reported in but three of his reactions. These were "auditory-verbal, no motor, and repeated the words of the problem or one or two words in the thought." In the experiment with the verbal distraction, the problem was readily solved with the consciousness of only a few visual images, and no feeling of distraction was present.

There were, however, three short pauses in his repetition of the letters. They may have been breathing pauses, but the reaction was merely 16.6 seconds long, which shows some inhibition may have been present. He also spoke out loud, during the visual distraction.

His conclusions came to him usually "like a flash." Of one he said: "not visual, I can't make out any sensory elements, it just came." Of another he said: "No terms at all. In terms of itself. Distinctly non-sensory. I was aware of it and it was clear," adding: "I am as sure of what I have told you about my introspection, as I am about after-images." He also reported feelings of "direction," "determination," and "tendency forward," as well as "abstract" thinking.

When the problem was presented it usually brought to mind visual images. "The first thing I must do is to get the problem set. I would get along better than to go ahead without knowing what the problem is (not verbal, bare thought)"; "throughout is a feeling of determination. What I am doing is in harmony with the task: no mind wandering." Whether this set was usually present or not, he did not report.

He seldom mentioned talking to himself, but many of his reports were of this sort: "I thought, how else could you do that?" "Then I asked myself, can we?" "Then I thought, oh yes, rote memory," etc. "Then I thought there is no need of staying here, for it is not new." "Then I thought I am no better off here than before." These instances were not described as verbal elements or recognized as such, but they seemed to represent a discursive element which characterized his thinking. It could not have been detailed or distinct, for it was sharply differentiate from the verbal elements; but that form of report was given so constantly it seemed to have been typical of his thought processes.

CHAPTER IX.

GENERAL CONCLUSIONS

Silent thinking, or the reaching of novel conclusions without the aid of explicit forms of behavior, may be carried on in very short periods of time.[1] It may be accompanied by a consciousness of concrete imagery[2] without any consciousness of verbal elements.[3] Or, it may be accompanied by a consciousness of verbal elements independent of concrete imagery, as when the individual talks or argues to himself.[4] These extremes, however, are not frequent, for thinking is usually accompanied by a consciousness of both concrete imagery and verbal elements.[5] In general, the more rapid the thinking, the more frequent are these details in consciousness.[6]

This consciousness of concrete and verbal details accompanies but part of thinking.[7] The remaining part of thought is imageless consciousness, independent of both concrete imagery and verbal elements. This imageless consciousness intervenes between periods of imagery.[8] Some of it may be accounted for in terms of inhibition in mental processes.[9] But a greater part of it bears an intimate relation to the development of the thought.[10] In fact, this imageless consciousness frequently characterized the actually novel part of the thinking,[11] and even accounted for the entire solution of some instances of rapid thinking.[12]

An individual is noticeably quiet when he is actually thinking, for a pause in movement is usually apparent just before the thinker indicates that he has reached a novel conclusion.[1] Such a pause is noticeable, even when the implicit movements of inner speech are being measured.[2]

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[1] Average time of 150 reactions was 50.7 seconds.

[2] Problems were selected which would stimulate the presence of concrete imagery as much as possible.

[3] In 24 of 150 reactions.

[4] In 11 of 150 reactions.

[5] In 110 of 150 reactions.

[6] In Sitting II. speed of thinking and imagery were correlated .45 while rapid thinking and imagery were correlated .55. In Sitting III. these correlations were respectively .21 and .59. Of the combined 100 reactions, these correlations were respectively .18 and .506.

[7] 51.6% of time in 100 reactions.

[8] In 99 of 150 reactions.

[9] 89 of 252 such periods were described by the subjects as "breaks," "gaps," and "periods of waiting."

[10] 130 of 252 such periods were described by the subjects as being accompanied by a feeling of progress.

[11] In 21 of 150 solutions.

[12] In 5 reactions.

Throughout thinking, slight vaso-motor and respiratory changes take place. The volume of the arm shows a slight tendency to increase gradually until the novel conclusion is reached.[3] The rate of heartbeat shows a slight increase at the beginning of the thinking and then alternately increases and decreases until the conclusion is reached.[4] Respiration tends to be more superficial and rapid after the problem is presented, becoming more regular as the solution is being reached.[5]

Verbal elements in thinking are frequently accompanied by noticeable lip movements[6] and by minute movements of the tongue and larynx.[7] Visual images in thinking may be closely related to ocular movements[8] and in many instances are inseparably connected with them or with a condition of visual fixation.[9]

The failure of imagery to be constantly present in thought, the lack of verbal elements in the solving of many problems, and the absence of both in some instances, point to thinking as a conscious process underlying these varying accompaniments.

Although implicit forms of behavior accompany thinking to a noticeable extent,[10] even these movements tend to disappear as the novel conclusion is being reached. Thinking takes place too rapidly to consist merely in a series of sensori-motor reactions. The time taken in reaching a new conclusion is very much less than the time needed to describe the same process to others. With memory visual images, slight eye movements might accompany the reproduction through associations with the visual details originally seen, but these would not be necessary for visual imagination images.[1] Familiar verbal phrases might through habit reproduce their corresponding articulatory movements. With novel ideas, on the other hand, such movements would not be as likely to occur.[2] Moreover, movement is sometimes intentionally resorted to in order to make details clearer, since it arouses sensations of the movements, which may in turn arouse further associations.[3]

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[1] In 115 of 150 reactions. This pause was not as conspicuous in solutions which were discarded because they were not novel to the subject (21 of 49 reactions showed this pause).

[2] In 5 of 12 reactions.

[3] In 7 of 12 reactions.

[4] In 6 of 12 reactions. The remaining pulse records show no common characteristics.

[5] In 6 of 12 reactions. The remaining breathing curves show no common characteristics.

[6] Observed by the experimenter in 32 of 74 instances.

[7] See above Table XV.

[8] Observed by the experimenter in 37 of 92 instances.

[9] See above pp. 59 ff.

[10] Minute relevant movements were those most apparent in Sittings I and II., while the correlations between thinking and inner speech in Sitting V was .606.

Furthermore, the arousal of movement by imagery requires a strength of stimulus adequate to pass from the sensory areas out through the efferent neurones. Visual and verbal images, which have been differentiated from others of their kind by merely their lack of clearness and detail, may be examples of imagery so weakly stimulated that the energy from that center is not sufficient to arouse accompanying movement.[4] This seems to afford evidence that is in support of the theory that thinking may be other than a mere series of sensori-motor arcs.

Thinking is a matter of association and, as this is a physiological process, it takes care of itself largely.[5] When the problem is presented the individual perceives the words and their meaning, but is at the same time aware that they constitute a problem. They describe a situation which is novel or unfamiliar, to which he must react. The novelty lies in the relationship which the terms of the problem bear to each other. The individual becomes aware of this relationship and realizes that he cannot solve that problem until he can reproduce the same relationship in terms of his own past experience. Take for example this problem: What picture would you select for the walls of a fifth grade school room? The terms are familiar, the novelty consisting in the relationship of the terms to each other. The individual realizes that the relationship is not familiar and that he has not a duplicate of this in his past experience, so that he cannot at once answer the question. To him, then, this constitutes a problem. By association each auditory sense impression made by the terms in the statement of the problem arouses its associates from the mass of past experiences and the individual attends to this process until some experience, which is partially related to all of the terms, is aroused by the stimuli. In this way the terms of the problem are brought into relationship by the connection of the experience which is related to each through contiguity or similarity. The physiological process is completed, as the stimuli set up by the perception of the various terms of the problem have reached some common association. At this moment the relationship is recognized by the individual as the one desired and the problem is solved. Thinking, therefore, is but a process of the recognition of a novel relationship between elements in one's past experience. The process of trial and error, with its accompanying selection and rejection of material, which takes place in securing the desired relationship, seems to be identical with that to which James has alluded in his description of the recall of a forgotten name finally recognized as the one sought.[1]

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[1] 37 of 69 memory images were found to have been accompanied with ocular movements while but 17 of 47 imaginary images have this characteristic.

[2] See above pp. 69 ff.

[3] See above pp. 72 ff.

[4] See above pp. 73 ff.

[5] The subjects frequently described the mental processes as progressing independently of their guidance. See above pp. 74 ff.

The thinker, then, is one who is able to turn his attention persistently to his conscious states. He must be one who can be aware of relationships as such and who can follow mental stimuli as they pass physiologically through brain paths, reproducing past experiences. The relationship required by the elements of the problematic situation must be sought. This is duplicated by a new grouping together of his past experiences, or, when this is lacking, in terms of experiences newly acquired from outside, such as in drawing a diagram, writing an outline, or reading relevant material. The vividness of the conscious states depends upon the degree of motor adaptation in attention, the source of control of the processes of association in thinking, as the degree of adaptation determines the degree of reinforcement of the physical stimuli.

Thinking need not be merely a series of sensori-motor arcs, for much of its activity might readily be limited to the cortical areas of the brain. In this way it might be, to a certain extent, literally a "mental reaction." The stimulation of the various sensory areas at the time the problem is perceived arouse duplicates of past sensory experiences. If stimuli, however, reach motor areas in the brain, and there is sufficient energy for them to be transmitted to the muscles, movements will result, the sensations of which arouse in turn stimuli for further associations in the brain. The consciousness attending cortical activity in the so-called "association areas," being neither sensory nor motor, would be accounted for in terms of the active states of imageless consciousness which have been found to characterize so much of silent thinking. As these imageless states occurred not only between periods of imagery i. e. between sensory areas in the brain, but also when novel conclusions were being attained,[1] the association areas might act as centers where stimuli from various areas in the brain can come together. Passive states of imageless consciousness, on the other hand, might be accounted for in terms of inhibitions, blockings in association processes, due to the various paths taken by the different stimuli.

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[1] James, W. Psychology, I. p. 257.

Thinking, as a reaction of this sort, would imply the transmission of the stimuli, aroused by the perception of the elements in a problem, throughout the brain as a nervous center. The stimuli, through associated brain paths, would bring about activity in any part of the brain. The areas stimulated would be of importance only as they proved to be the source of experiences which would make possible the relationship required by the elements of the problem. Hence, images, movements and their consequent sensations, and imageless states of consciousness might, singly or all together, be the content of thought. Such an interpretation of thinking as this best explains the varied results secured in this investigation.

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[1] Woodworth, R. S. Non-sensory Components of Sense Perception. J. of Phil. Psych. etc. 1917, IV. pp 169 ff.

APPENDIX

EXPERIMENTER'S CODE

⊓	Forward motion of head.
⊓⊓⊓	Sidewise motion of head.
⊓⊓	Eye movement.
⊓⊓⊓⊓	Scowl.
⊓ ⊓	Lip movement.
⊓ ⊓⊓	Smile.
⊓ ⊓⊓⊓	Word spoken aloud.
⊓⊓ ⊓⊓	Right hand.
⊓⊓ ⊓	Left hand.
⊓⊓⊓ ⊓⊓	Right foot.
⊓⊓⊓ ⊓	Left foot.
┌─┐	Movement of body.
┌─┐ ┌─┐	Shrugging of shoulders.

PROBLEMS

For Sitting I.

1. How would you plan a trip to Iceland?[1]
2. If you were given unlimited funds to make a collection of some particular kind, what choice would you make?
3. What would be the best thing to do if you suddenly found yourself in the midst of an angry crowd which was pushing forward to commit some act of violence?
4. What would you do if you saw a person running in the street after her dress had caught fire?
4. If you were going to be away from all civilization for a year and could take only four books, which ones would you choose?
6. How would you manage if you had a blue serge dress and only half a yard of red silk to trim it with?
7. What do you consider is the best training for a girl (or boy) between fourteen and twenty years of age who is the daughter (or son) of extremely wealthy parents?
8. What do you think is the best way to teach geography to children?
9. During what years is the best time to teach it?
10. If you had only four days for a vacation and $75 to spend on it, where would you go?
11. Of what would you make your meal if three unexpected visitors came in at lunch time, and you had on hand merely a can of corn and a can of sardines, beside the ordinary supply of staple products?
12. How would you plan a Hall of Fame?
13. If you had to select four pictures to hang on the walls of a fifth grade school room, what would you choose?

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[1] Suggested by test in Angell, Report of Com. of Am. Psych. Ass. on Standardization of Procedure in Experimental Tests. Psych. Rev. Mon. XIII. 1910. No. 53, p. 98.

PROBLEMS

For Sitting II.

1. If you had to give a lecture about the effect of moving pictures on the child mind, how would you arrange your material?
2. Five hundred years ago the automobile, the air ship, and the steam railroad were entirely unknown means of locomotion. If anyone then had said that today we should be traveling by these means, his statement would have been an economic prophecy. Will you yourself make an economic prophecy in regard to future methods of locomotion?[1]
3. Will you make an economic prophecy in regard to future methods of heating?[1]
4. Will you make an economic prophecy in regard to future housing conditions?[1]
5. Will you make an economic prophecy in regard to future eating conditions?[2]
6. How would it be possible for an automobile to be so constructed that it could be used at any moment as a flying machine?
7. How do you think an instrument could be made which would turn the leaves of sheet music?[1]
8. What would be the probable consequences if the seas could be owned by individuals as the land is?[1]
9. If you had only one hour in which to show the city to some visitors what would you do with them?
10. What is the best kind of a sidewalk to build on an uphill road?
11. What color scheme would you select for decorating the library in your own home?

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[1] Chassell, L. M. Tests for originality. J. of Ed. Psych. VII. 1916, p. 322.

PROBLEMS

For Sitting III.

1. What would happen if our supply of paper should cease?[1]
2. If you were alone on a high point of land and had to attract the attention of a person a mile away, what would you do?
3. What would be likely to happen if it were agreed that each individual owned the atmosphere for 500 feet above his property?
4. How would you go about it to find out whether good spelling depended more upon logical memory than upon rote memory?
5. If you were building a house in the country, what kind of a front entrance would you design for it?
6. If the possession of wealth were universally considered dishonorable, how would it affect the cost of living?[1]
7. If you had unlimited funds to found a new perodical, what kind would you choose to start?
8. If you should start now for the Battery, how could you possibly reach there in half an hour?
9. On what historic character could one write a good play?
10. If you were asked to write a magazine article about the Montessori Method, how would you arrange your material?
11. If you were leaving an empty house and your skirt caught in the door which locked itself and for which you had no key, what would you do?
12. How would you entertain a party of blind children?

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[1] Chassell, L. M. Tests for Originality, J. of Ed. Psych. VII. 1916, p. 322.

PROBLEMS

For Sitting IV.

1. Visual Distraction (swinging object.)
    1. How would you make an instrument which would rule a blackboard off into squares of any size?
    2. What would be the best kind of a fire-escape to install on crowded dwelling houses?
2. Auditory Distraction (bell rung continually.)
    1. What two musical artists do you think would attract the largest audiences today if they gave a program together?
    2. What do you think is the most inspiring march music?
3. Verbal Distraction (counting aloud a, b, c, a, b, c; etc.)
    1. How would you teach a young child motor coordination?
    2. What four points would you especially emphasize if you were giving a college course in literature?
    3. How much money do you think Barnum & Bailey's circus takes in at one performance when they have a full attendance?
4. Motor Distraction (finger play.)
    1. How would you divide an angle into three equal parts?
    2. How would you fold a circular piece of paper so that cutting it in one place, you would have four separate triangles cut out of it?[1]

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[1] Suggested by Binet & Simon. A Method of Measuring the Development of the Intelligence of Young Children. Tr. by C. H. Town, p. 81.

PROBLEMS

For Sitting V.

1. If you had only one hour in which to show the city to some visitors, what would you do with them?
2. If the possession of wealth were universally considered dishonorable, how would it affect the cost of living?[1]
3. How do you think an instrument could be made which would turn the leaves of sheet music?[1]
4. If you were asked to write a magazine article about the Montessori Method, how would you arrange your material?
5. If you were to select street signs for some city, what kind would you choose?
6. What occupation is best fitted for the blind to fill?
7. What stories would you tell to amuse a six year old girl for an hour?
8. If you wanted to find the person who owned the oldest piano in the United States, how would you go about it?
9. If a clock's hands were set at quarter of three and the hands were turned back one and two-thirds revolutions, what time would it then be?[2]

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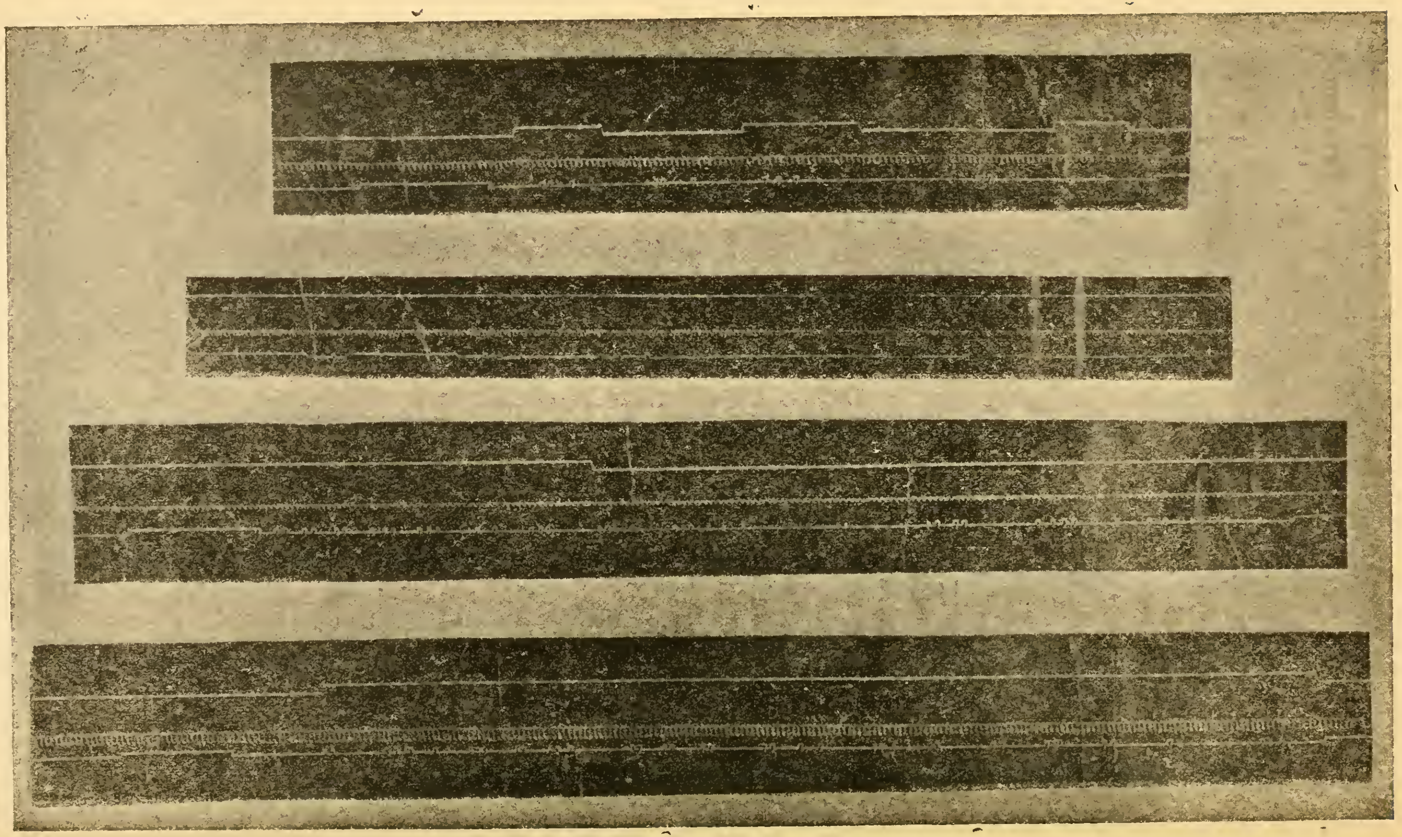
[1] Suggested by test in Chassell, op. cit. p. 323.

[2] Suggested by Test XV. 3, in Goddard, H. H. The Binet-Simon Measuring Scale for Intelligence Revised. The Training School, 1911.

STIMULUS WORDS FOR TEST II IN IMAGERY TYPES

		Problem
1.	Dwelling house	IV 2
2.	Soldiers	
3.	Wealthy parents	I 7
4.	Iceland	I 1
5.	Dress	I 6
6.	Books	I 5
7.	Flying machine	II 6
8.	Committee	IV III 3
9.	Fire	
10.	Magazine	III 10
11.	Hall of Fame	I 12
12.	Battery	III 8
13.	Collection	
14.	Visitors	I 11, II 9
15.	$1,000	IV, III 3
16.	Crowd	I 3
17.	Vacation	I 10
18.	Accident	
19.	Sheet music	IX 7
20.	Automobile	II 6

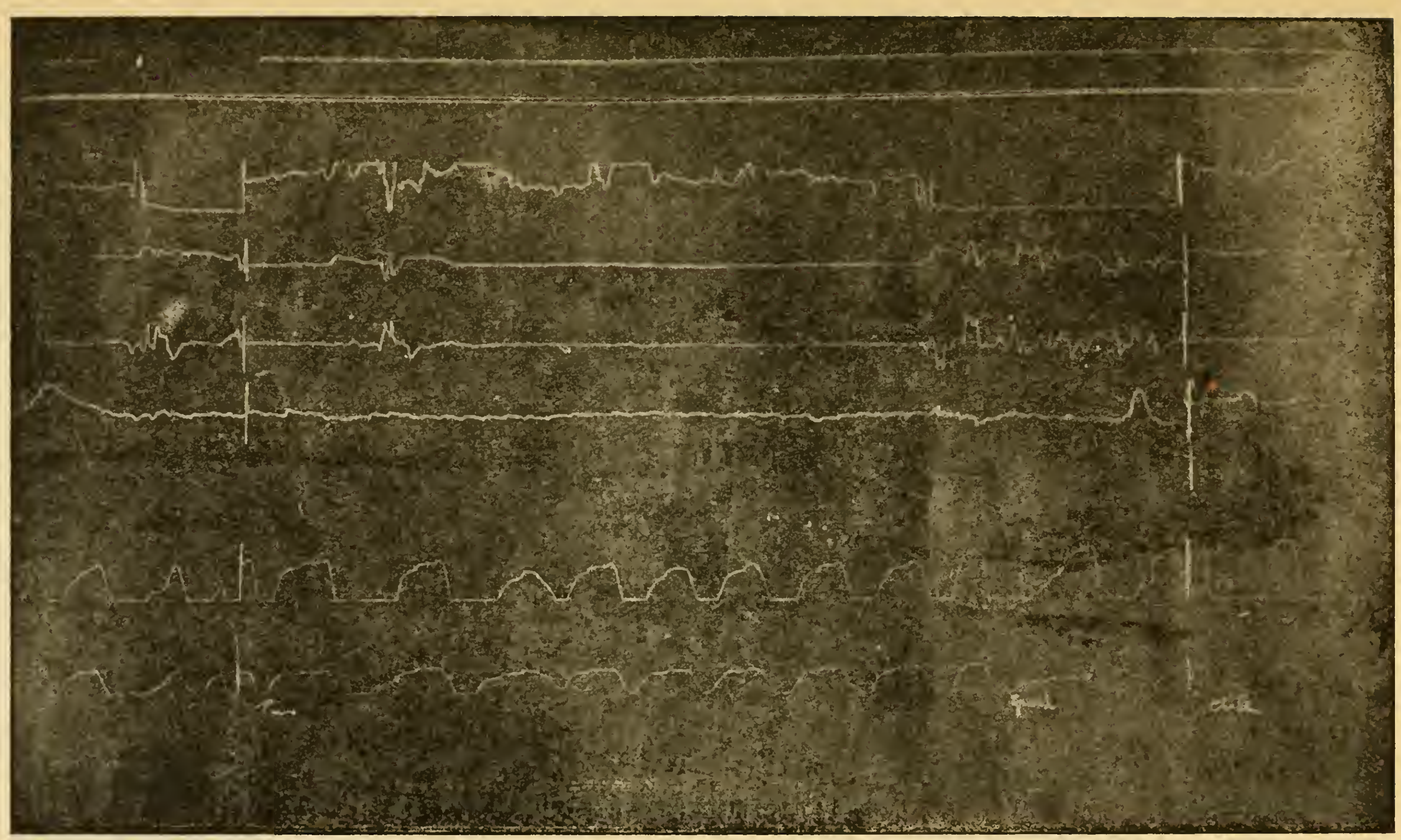
Fig. 8



Typical Kymograph Records of Sitting II.

1st line, record of subject's key showing presence and absence of imagery.
2nd line, record of time in fifths of seconds.
3rd line, record of experimenter's key, showing in code movements made by subject.

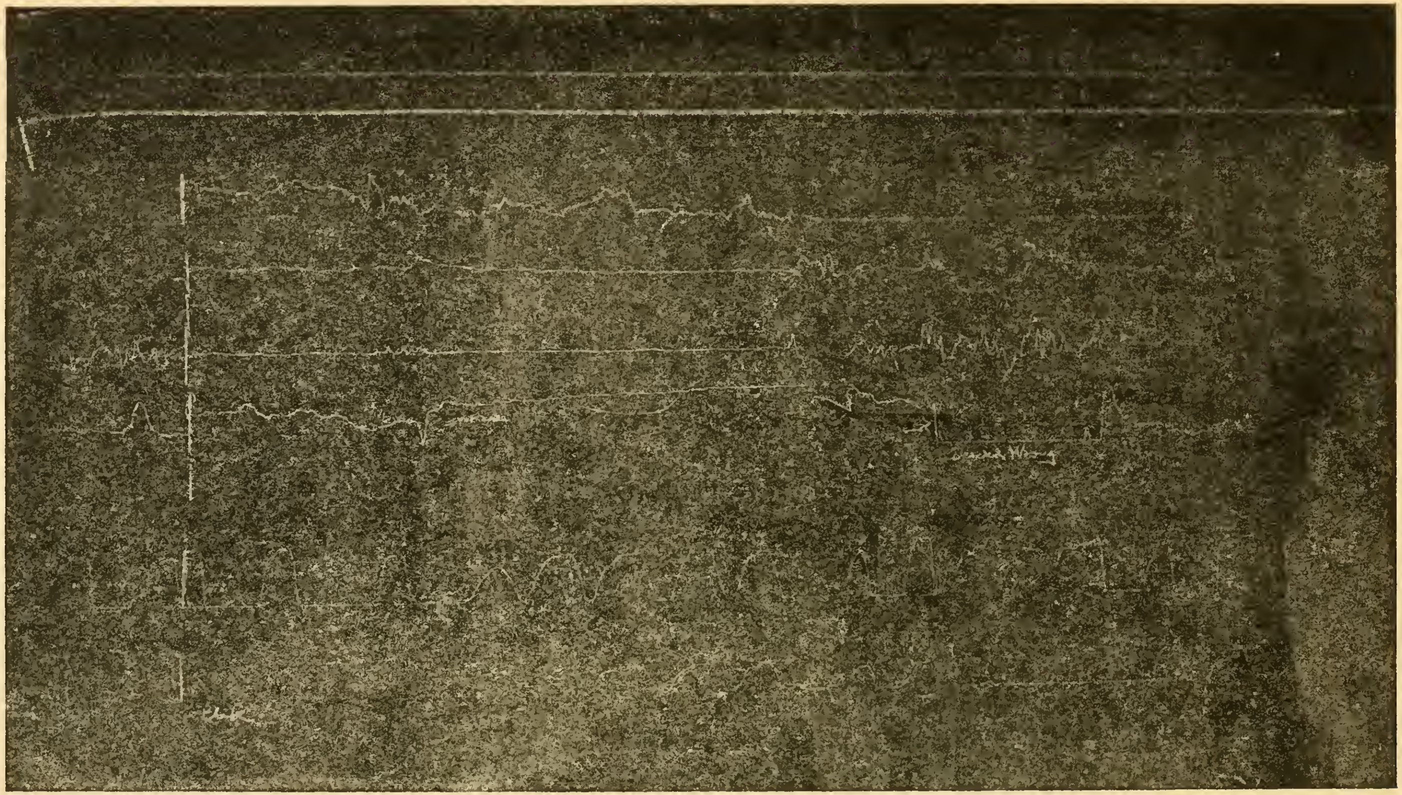
Fig. 9



Typical Kymographic Record of Sitting V. Subject A. Problem 8.

1st line—Time of presentation of problem and of subject's thinking.
2nd line—Time record in fifths of seconds.
3rd line—Record of tongue movements.
4th line—Vertical movements of larynx.
5th line—Horizontal movements of larynx.
6th line—Plethysmographic record.
7th line—Record of thoracic respiration.
8th line—Record of abdominal respiration.

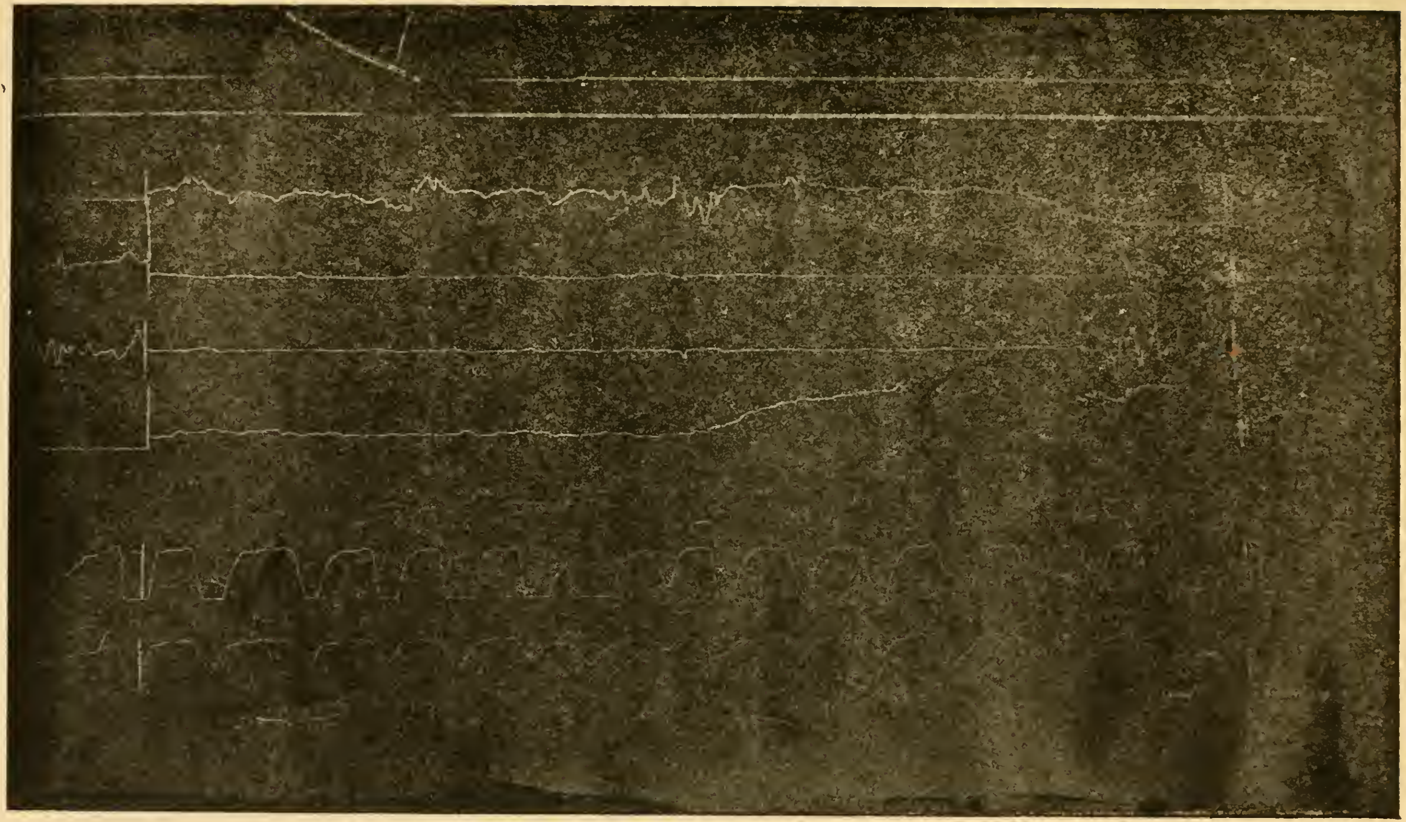
Fig. 10



Typical Kymographic Record of Sitting V. Subject B. Problem 9.

1st line—Time of presentation of problem and of subject's thinking.
2nd line—Time record in fifths of seconds.
3rd line—Record of tongue movements.
4th line—Vertical movements of larynx.
5th line—Horizontal movements of larynx.
6th line—Plethysmographic record.
7th line—Record of thoracic respiration.
8th line—Record of abdominal respiration (after the subject had given the signal that she had finished, she decided that she had given the wrong answer).

Fig. 11



Typical Kymographic Record of Sitting V. Subject C. Problem 1.

1st line—Time of presentation of problem and of subject's thinking.
2nd line—Time record in fifths of seconds.
3rd line—Record of tongue movements.
4th line—Vertical movements of larynx.
5th line—Horizontal movement of larynx.
6th line—Plethysmographic record.
7th line—Record of thoracic respiration.
8th line—Record of abdominal respiration.

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